PROEFSTATION VOOR TUINBOUW ONDER GLAS TE NAALDWIJK

The influence of the water to air ratio in glasswool on yield and root distribution of a gerbera crop

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SUMMARY

To detect the influence of the water to air ratio for a gerbera crop a range of water to air ratios was created in glasswool. One rockwool substrate was included in this trial. Gerberas of the cultivars 'Nova' and 'Video' were planted in week 26 of 1993. The trial was finished in week 22 of 1993. The air percentages of the treatments were caused by the pore size, the slab height and extra leaching by a 'flap'. The air percentage for the glasswool treatments were 1, 11, 11 ,41 and 66 %. The air percentage in rockwool was 18 %.

Because the gerbera roots grew practically straight downwards, the substrate was used only partly by the roots. In glasswool with small pores (1-11% air) the roots were more dispersed than in the other treatments. In 7.5 cm slabs (11% air) of the same pore structure the rooted volume was higher than in 5 cm slabs (1 and 11 % air). The quantity of roots outside the slab was important for all substrates, at a slab height of 5 cm the quantity of roots outside the slab was about 50% higher (1, 11, 41 and 66 % air) than at a height of 7.5 cm (11 and 18% air).

The yield on 7.5 cm slabs was higher than on 5 cm slabs. The yield of 'Nova' on 7.5 cm glasswool and rockwool was equal. 'Video' on 7.5 cm rockwool (18 % air) gave higher yield than on 7.5 cm glasswool (11 % air). Because the air percentage in rockwool was not covered by the range of air percentage of glasswool in this trial the comparison between glasswool and rockwool is not possible.

A 7.5 cm slab of glasswool with a higher air content (about 20 %) seems favourable for the crop. If the structure in glasswool with small pores caused better root dispersion an increase of the air percentage in this glasswool type will probably give a higher yield.

SAMENVATTING

Gerbera's van de cultivars 'Video' en 'Nova' zijn geteeld op vijf glaswol substraten en steenwol tussen week 26 van 1992 en week 22 van 1993. De luchtpercentages in de behandelingen zijn gevarieerd met behulp van de poriëngrootte, de matdikte en extra drainage met flap.

Het luchtgehalte in de verschillende glaswolbehandelingen was 1, 11, 11, 41 en 66 %. Het luchtgehalte in steenwol was 18 %.
Doordat de gerberawortels vrijwel recht naar beneten groeiden werden de substraten slecht benut. In glaswol met fijne porien (1-11% lucht) waren de wortels meer verspreid dan in de overige behandelingen. In 7.5 cm matten van het zelfde glaswoltype (11% lucht) was het bewortelde volume groter dan in 5 cm matten (1 en 11% lucht). De hoeveelheid wortels buiten de mat was aanzienlijk voor alle substraten, bij een mathoogte van 5 cm was de hoeveelheid wortels buiten de mat ongeveer 50% hoger (1,11,41 en 66 % lucht) dan bij de 7.5 cm matten (11 en 18% lucht).

De opbrengst op 7.5 cm dikke matten was hoger dan op 5 cm matten. 'Video' op 7,5 cm steenwol (18% lucht) gaf een hogere produktie dan op 7.5 cm glaswol (11% lucht). Doordat het luchtgehalte in steenwol niet overeen kwam met de reeks luchtgehaltes in glaswolbehandelingen uit de proef is de vergelijking tussen steenwol en glaswol in deze proef niet goed mogelijk.

Luchtgehaltes in glaswol tussen 10 en 40 % lijken interessant voor nader onderzoek. Als de struktuur in glaswol met fijne poriën verantwoordelijk is voor een betere wortelverdeling kan een toename van het luchtgehalte in glaswol waarschijnlijk leiden tot een hogere produktie.

1 INTRODUCTION

This trial is part of the glasswool project at the PTG in Naaldwijk. The project is financed by Isover/CRIR. The aim of this research is to study the possibilities of different types of glasswool in horticulture.

Since June 1992 gerberas were grown on glasswool. This report describes the set-up and the results of this trial. In the whole glasswool project much attention is given to the water to air ratio in the substrate. In this trial we tried to create an optimal root environment without limits for the irrigation strategy. For this we used glasswool substrate with different water to air ratios. The trial was carried out at PTG in Naaldwijk.

2 MATERIAL AND METHOD

2.1 Plant propagation

Gerbera plants were propagated by "Look Action" in Den Hoorn. The cultivars 'Nova' and 'Video' were grown. Both cultivars give a large flower production. Nova is sensitive to unfavourable conditions; 'Video' grows more easily.

Gerbera tissue-culture plants propagated in rockwool plugs were placed on Cultilène rockwool cubes in week 22 (1992). The plants were directly planted after delivering in week 26 at PTG.

2.2 Substrates

Six substrate treatments with different water to air ratios were applied. The water to air ratios were managed in 3 ways namely the height of the slab, the poresize and forced leaching by a 'flap' under the glasswool.

Under growing conditions glasswool with big pores is drier than glasswool with small pores. glasswool with a 'flap' is drier than glasswool without 'flap'. The mean air content in glasswool with the same physical properties becomes higher when the thickness of the slab increases. By combining these factors it is possible to create different water to air ratios in glasswool. A 'flap' under the substrate resulted in a higher air content in the glasswool. The increased air content could be especially important for the conditions in the bottom layer because normally this layer is saturated with water.

The six treatments applied in this trial were :
1) glasswool with small pores height 7.5 cm, width 13.3 cm
2) Cultilene rockwool type 1 height 7.5 cm, width 13.3 cm
3) glasswool with small pores height 5 cm, width 20 cm
4) glasswool with small pores height 5 cm, with a glassfilm slab of 2.5 cm
5) glasswool with big pores height 5 cm, width 20 cm
6) glasswool with big pores height 5 cm, with a glassfilm slab of 2.5 cm

The glasswool was wrapped in plastic sleeves. The available substrate volume for each plant was identical in all the treatments. The width of the 5 cm thick slabs was 20 cm and the width of the 7.5 cm thick slabs was 13.3 cm. The length was 100 cm for all slabs.
The thickness of the slabs is measured at the end of the trial.

2.3 Root distribution

An indication of the root distribution was obtained in three ways : the number of primary roots, the estimated rooted volume and the fresh weight of roots outside the slab. Two average plants of each unit were determined.

The number of primary roots were counted at the cut-surface at 2.5 cm under the plant block.

The rooted volume within the substrate was obtained by measuring the root surface at 2.5 cm under the cube. For this the substrates were cut in two slices. The dispersion was measured in the length and width of the slab. With these values the surface of the roots was calculated. For the estimation of the rooted volume this surface was multipled with the thickness of the substrates.

The fresh weight of the roots outside the slab was also determined. The roots were cut off and weighed.

2.4 Greenhouse equipement

The greenhouse of 189 m^2 was divided into six indepedent recirculation units. Each unit consisted of 4 replicates of 30 plants. The plant density was 6.25 plants per square meter. A plan of the set-up of the trial is given in table 1 of appendix 1. The climate was controlled by the computer.The slabs were placed on 10 cm thick polystyrene supports in a gutter. In this way water leached out very easily and there was little chance for root contact with water outside the substrates.

2.5 Culture

The drainholes were made at the beginning and end of each slab. To assure the watersupply for all the treatments a high leaching fraction was maintained and the applications were managed during 24 hours. The irrigation frequency was calculated by the computer according to a transpiration model developped at the PTG. Each time the calculated transpiration reached the setpoint value an application of 90 ml took place. The target leaching fraction was 60% (of the gift). The realised leaching fractions during the culture are shown in table 2 of appendix B.

The climate was established according to the advise of the DLV (advisory service). The flowers were harvested once a week in the winter and two times a week in the other periods of the year. After the culture 5 plants per unit were weighted.

3 RESULTS

3.1 Water to air ratio

The average water content in the substrates was measured on 19 April 1992 with a water meter. The results are shown in figure 1, the data are given in table 3 of appendix C. The water content in all glasswool treatments with small pores did not differ signifycantly. The water content in rockwool was significantly lower than in 5 cm glasswool with small pores without 'flap' but equal to the 7.5 cm thick slab and the 5 cm thick slab with 'flap'. The water content of glasswool treatments with big pores differed significantly from the other treatments.

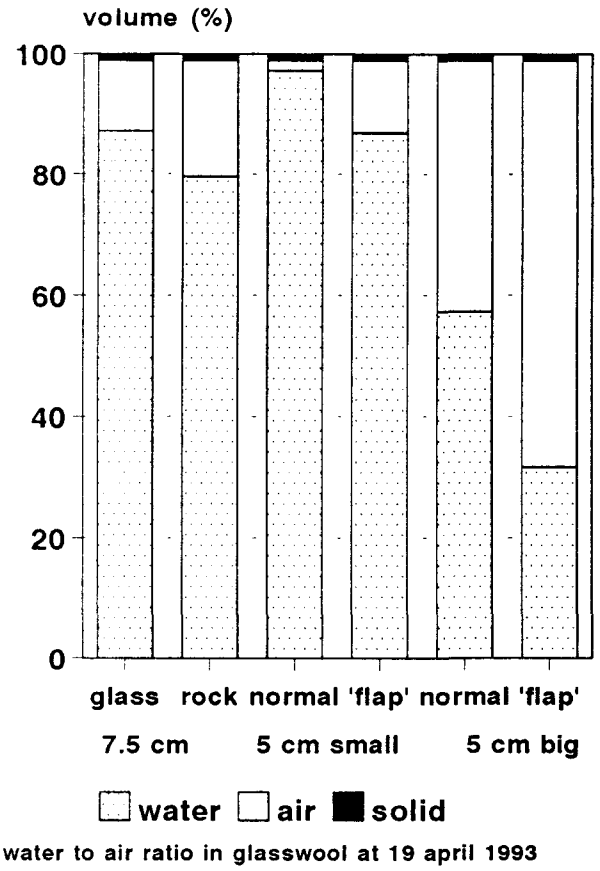

figure 1: water to air ratio in glasswool at 19 april 1993

3.2 Root distribution

Gerbera contineous forms new roots growing downwards. An example of the root system is shown in figure 2. When the main roots reached the

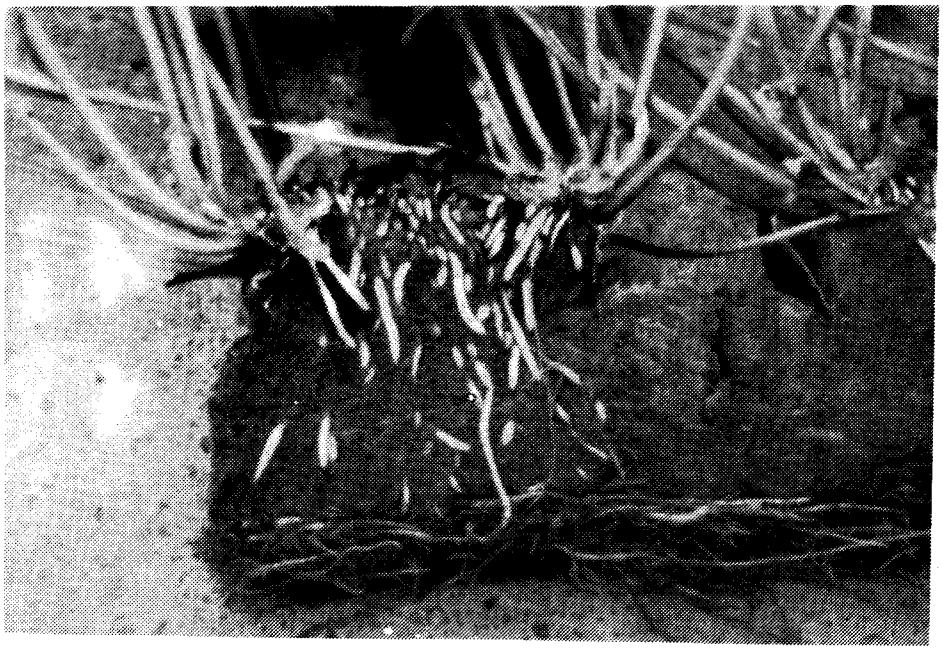

figure 2: gerbera roots; longitudinal section of a rockwool slab.

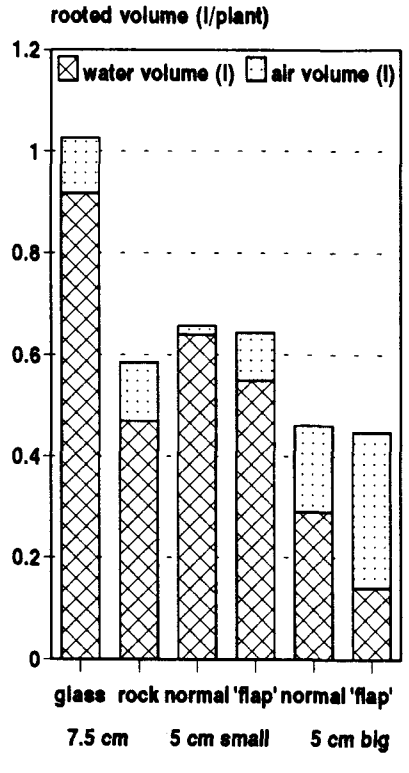

figure 3: gerbera 'Nova' estimated water and air volume available for each plant.

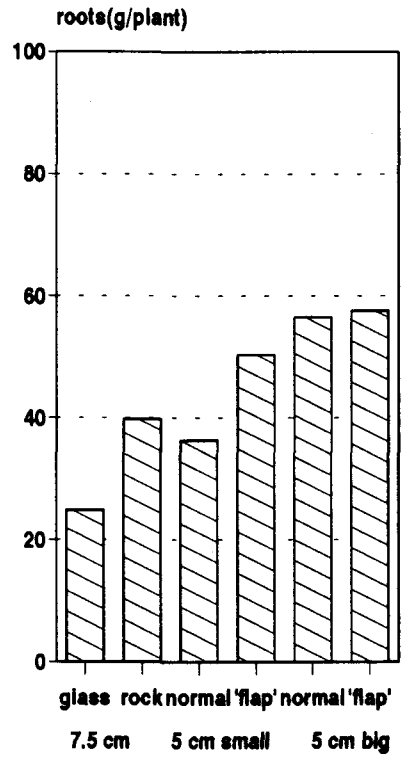

figure 4: gerbera 'Nova' root quantity outside the slab (g fresh/plant).

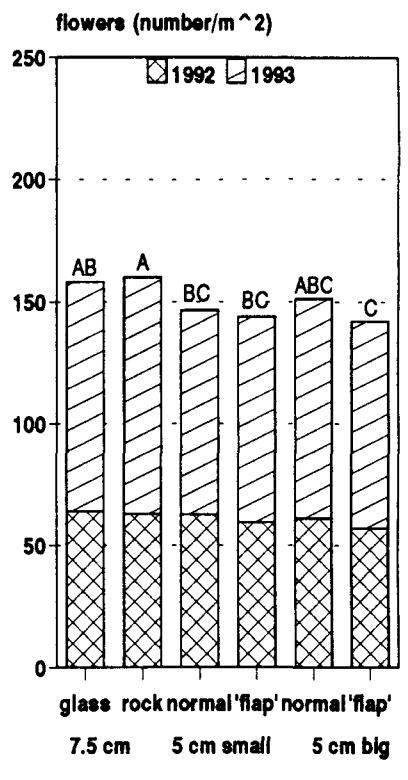

figure 5: gerbera 'Nova' yield 1992/1993 (number first class/m^2) '

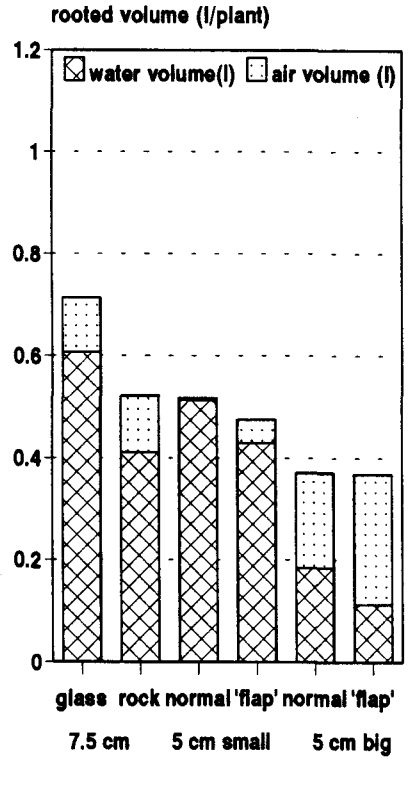

figure 6: gerbera 'Video' estimated water and air volume available for each plant.

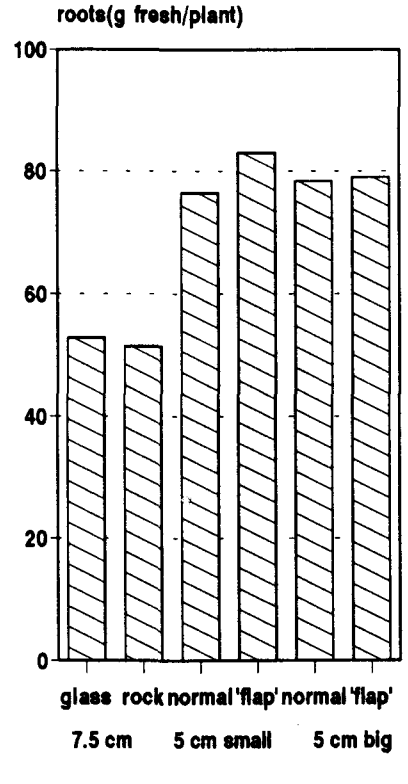

figure 7: gerbera 'Video' root quantity outside the slab (g/plant).

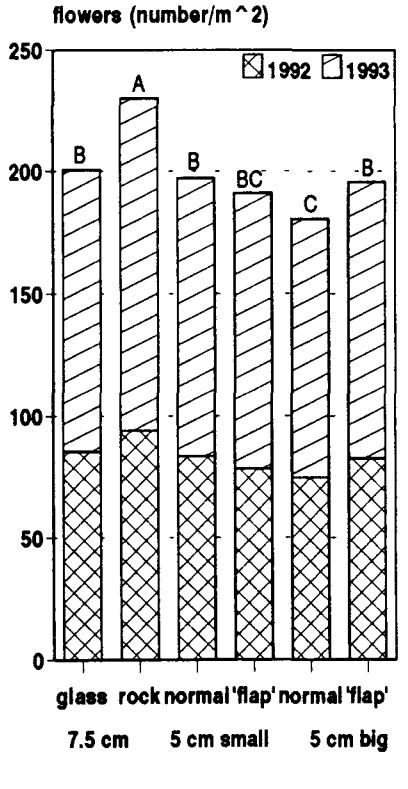

figure 8: gerbera 'video' yield 1992/1993 (number first class/m^2) '

'If two treatmenns do not have a common letter the yield differed significantly.

bottom of the slab they left the glasswool and grew further under the slab. The substrate between two plants was not used totally by the roots, only a small layer at the bottom of the slab was used.

The counted number of main roots, growing downwards from the plant to the bottom of the slab, did not differ for the substrates.

The estimated, rooted volume of gerbera 'Nova' and 'Video' is shown in figures 3 and 6 respectively. 'Video' had a significantly lower rooted volume than 'Nova'. The rooted volume in 7.5 glasswool was significantly higher than the other treatments. The rooted volume of three treatments, 7.5 cm rockwool and both 5 cm glasswool with small pores was equal, and significantly higher than the 5 cm glasswool with big pores. There was no interaction between the cultivars and the substrates.

The fresh weight of the roots outside the substrate is shown in figures 4 and 7. The rootweight of the 5 cm slabs differed significantly with the 7.5 cm slabs. Other differences were not significant. The data of these figures are given in tables 4 to 6 of appendix D.

3.3 Yield

The number of first quality flowers of gerbera 'Nova' and 'Video' in 1992 and 1993 is shown in figures 5 and 8, respectively. More results, as quality of the flowers and the distribution of the yield over the season, are given in tables 7 to 11 of appendix E.

The results of 1992 were confirmed in 1993. The highest production was found for the 7.5 cm thick substates. Video on 7.5 cm rockwool gave significantly higher production than on 7.5 cm glasswool. The yield among the 5 cm substrates did not differ significantly. No significant differences were found for the quality of the flowers. The mean flower weight of the wettest treatment (5 cm glasswool, small pores without flap) was significantly lower than the other treatments (table 9).

The fresh weight of the plants, determined at the end of the culture, is given in table 12 of appendix E. The plants on rockwool were significanlty heavier then the glasswool treatments.

3.4 Durability of the substrates

The force of the gerbera roots was strong. The thickness of all substrates was decreased (table 5). The thickness of the 7.5 cm glasswool and rockwool was equal at the end of the culture. The thickness of the 5 cm slabs was significantly less decreased than the 7.5 cm slabs.

3.5 Chemical analyses

Samples of the nutrient solution were analyse frequently by the B.L.G.G. The results of the analyses are shown in tables 13,14 and 15 of appendix F.

4 DISCUSSION

The air percentage measured on 19 April in the 7.5 cm glasswool of 11 % was low. The air percentage in this glasswool type applied in a cucmber crop (autumn 1993) increased from 10 % after three weeks to 20 % after ten weeks (after planting). De difference of air content between the cucumber slabs and the gerbera slabs could be explained by the appearance of hysteresis in the slabs. The gerbera crop had, compared to the cucumber crop, a little dispersion of the roots and a small distance between two drippers. There was no water uptake between two plants, by the regular supply of water hysteresis did not occur in that part of the substrate. The small distance between two drippers resulted in an adjustment of the waterbuffer in the whole slab.

Many factors were of influence on the final results. In this trial several observations, as rooted volume, water and air percentage and root quantity under the slab were made. The importance of each observation for the gerbera crop is unknown, therefore the interpretation of results is difficult. The question is if the a parameter was in a realistic range to influence the yield.

The expectation is that more roots under the slab and a lower rooted volume is unfavourable for the crop. The water to air ratio in the rooted volume could also be of influence for the plant. A minimum air percentage is necessary to assure the oxygen transport to the roots. The oxygen diffusion depends on the pore structure so the minimum air content, necessary for the oxygen supply to the roots, could be different for each substrate type. At a high water percentage the water flows more in the horizontal direction of the substrate so the nutrient solution will be refreshed in a bigger volume of the substrate. (P. van der Avoird, waterstroming in glaswolsubstraten, Naaldwijk, maart 1993)

In glasswool with small pores the roots were more dispersed than in glasswool with big pores. It is not clear what caused this dispersion. It could be either the structure of the glasswool, the low air content or the high water content in the slab. The high dispersion of the roots in glasswool with small pores did not increase yield. The air-content in all "fine pores" treatments was low. Perhaps the low air content combined with the high irrigation frequency gave insufficient oxygen supply to the plants. In that case the advantage of the bigger rooted volume of each plant in glasswool with small pores was annulled by a shortage of oxygen. Another explanation could be that the rooted volume was not a limiting factor for the yield. More research about the demands and functioning of the root system is necessary to know the real cause.

The roots outside the substrate, under the slab, had probably contributed to the functioning of the plant, so the influence of the substrate on the production was not determined purely. The amount of roots outside the slab depended on the substrate and the crop (cultivar). In this trial the roots under the slabs were vital. In critical situations, as infection with plant diseases or water stress however, the roots under the substrate could be more sensitive than roots within the substrate. Consequently, a big root quantity under the slab is less favourable.

The air content in glasswool with big pores was high. The rooted volume, however was small caused by little dispersion of the roots and a slab thickness of only 5 cm. The available quantity of water in the rooted volume was low (figures 3 and 6).

An explanation for the high yield of gerbera "Video" on 7.5 cm rockwool could not be found in this trial. Specific properties of rockwool (as structure of the wool, buffering of the pH, ...) could be favourable for the gerbera "video" crop. Another explanation could be the favourable water to air ratio in rockwool, the air content of 20% was intermediate the air content in dry (big pores) and wet (small pores) glasswool. Because the range of air percentages in glasswool did not cover the air content of rockwool it was not sure whether the conditions in one of the glasswool treatments were optimal for maximum yield. Perhaps the oxygen supply to the roots was not sufficient in the wettest glasswool treatments and the low water percentage in the driest glasswool treatments was not optimal for the yield.

5 CONCLUSIONS

- The rooted volume depended on the slab height and the substrate type in this trial. Gerbera plants use only a vertical cylinder of substrate under the plant block. The diameter of this cylinder was larger for the glasswool with small pores than glasswool with big pores and rockwool.

- The higher dispersion of the roots in glasswool with fine pores could be caused by the structure of the substrate, the high water content or the low oxygen content.

- The root quantity under the slab became higher when the water content in the slab decreased.

- glasswool research for a Gerbera crop is very difficult. The quantity of roots outside the slab is important and differ for the applicated glass wool types this will disturb the results.

6 RECOMMENDATIONS

- For gerbera higher substrates and/or higher plantblocks are interesting to increase the rooted volume because gerbera uses only a cylinder of substrate under the plant block.

- The relation of the root dispersion and the substrate type is very promising. If the larger dispersion of gerbera roots was caused by the fibre type and the oxygen supply was limited by the low air content an increase of the air content might increase oxygen supply and with that the yield.

- glasswool types with an average air content between 10 and 40 % seem to be of interest for further research.

- To keep the roots within the slab a relative high water content of the substrate is desired.

- To compare glasswool with rockwool it is necessary to choose at least comparable air supplies of the root systems. Because the structure of the substrate could influence the oxygen diffusion the best comparison is to test a range of air contents in both substrates.

- The irrigation was identical for all treatments and adapted to the driest treatments. A lower irrigation frequency will give a larger water uptake between two applications. This could be favourable for the oxygen supply of the roots (Intern verslag nr 14, juli 1993, PTG)

Appendix A

table 1: plan of the gerbera trial in greenhouse 211-10 with field number and distribution of the treatments.

10	5	12	2	3	8	1	7	10	12	6	4
4	8	12	16	20	24	28	32	36	40	44	48
9	6	11	1	4	7	2	8	9	11	5	3
3	7	11	15	19	23	27	31	35	39	43	47
		repetition 2						repetition 4			
4	11	1	6	8	9	5	2	7	3	9	11
2	6	10	14	18	22	26	30	34	38	42	46
3	12	2	5	7	10	6	1	8	4	10	12
1	5	9	13	17	21	25	29	33	37	41	45
		repetition 1						repetition 3			

treatments

1) glasswool with small pores height 7.5 cm, width 13,3 cm; Gerbera 'Nova'
2) cultilène rockwool type 1 height 7.5 cm, width 13.3 cm; Gerbera 'Nova'
3) glasswool with small pores height 5 cm, width 20 cm; Gerbera 'Nova'
4) glasswool with small pores height 5 cm, with a glasfilm slab of 2,5 cm; Gerbera 'Nova'
5) glasswool with big pores height 5 cm, width 20 cm; Gerbera 'Nova'
6) glasswool with big pores height 5 cm, with a glassfilm slab of 2,5 cm Gerbera 'Nova'
7) glasswool with small pores height 7.5 cm, width 13,3 cm; Gerbera 'Video'
8) cultilene rockwool type 1 height 7.5 cm, width 13.3 cm; Gerbera 'Video'
9) glasswool with small pores height 5 cm, width 20 cm; Gerbera 'Video'
10) glasswool with small pores height 5 cm, with a glasfilm slab of 2,5 cm; Gerbera 'Video'
11) glasswool with big pores height 5 cm, width 20 cm; Gerbera 'Video'
12) glasswool with big pores height 5 cm, with a glassfilm slab of 2,5 cm; Gerbera 'Video'

Appendix B

table 2: water uptake, water supply and leaching fraction

period		water uptake	irrigation	leaching
begin	end	/day (l/m^2)	/day (l/m^2)	fraction (%)
10- 7	16- 7	0.567	5.00	89
16- 7	20- 7	0.475	6.75	93
20- 7	22- 7	0.700	9.50	93
22- 7	24- 7	1.300	14.00	91
24- 7	27- 7	1.100	11.67	91
27- 7	4- 8	1.963	13.38	85
4- 8	6- 8	1.450	12.50	89
6- 8	10- 8	1.225	6.75	82
10- 8	13- 8	0.900	3.67	77
13- 8	17- 8	0.875	5.00	83
17- 8	19- 8	1.300	4.50	72
19- 8	24- 8	1.000	4.20	76
24- 8	26- 8	1.350	4.50	69
26- 8	27- 8	1.600	4.00	60
27- 8	11- 9	1.273	3.60	65
11- 9	15- 9	1.175	4.25	73
15- 9	17- 9	1.450	4.00	63
17- 9	18- 9	1.300	4.00	67
18- 9	23- 9	0.920	2.20	57
23- 9	25- 9	1.350	3.50	59
25- 9	29- 9	1.375	3.50	61
29- 9	30- 9	2.000	5.00	62
30- 9	5-10	1.120	2.60	58
5-10	7-10	0.700	2.00	66
7-10	8-10	0.500	2.00	75
8-10	9-10	0.900	2.00	62
9-10	14-10	1.840	5.00	64
14-10	15-10	0.800	3.00	76
15-10	16-10	1.700	7.00	77
16-10	23-10	0.871	3.86	77
23-10	26-10	0.867	3.00	69
26-10	28-10	1.100	4.50	77
28-10	29-10	0.600	3.00	79
29-10	30-10	1.100	5.00	78
30-10	2-11	0.667	3.33	80
2-11	10-11	0.950	3.75	74
10-11	19-11	0.622	3.56	82
19-11	9-12	0.505	3.45	85
9-12	22-12	0.531	3.46	85
22-12	30- 1	0.287	1.48	81
30- 1	16- 2	0.629	3.82	84
16- 2	2- 3	1.071	4.64	77
2- 3	18- 3	1.100	5.44	80
18- 3	1- 4	1.593	6.29	75
1- 4	14- 4	1.515	5.46	72
14- 4	4- 5	2.300	6.25	63
4- 5	18- 5	2.314	6.50	65
18- 5	2- 6	2.347	5.87	60

Appendix C

table 3: data of the water content mesurements at 19 april 1993 (volume %)

	treatment					
	glasswool	rockwool	glassw. small pores		glassw. big pores	
cultivar	7.5 CM	7.5 CM	wet	dry	wet	dry
Nova	88	79	96	84	62	31
Video	86	81	98	90	53	33
average	87	80	97	87	57.3	32
group	ab	b	a	ab	c	d

Appendix D: Data of the root distribution

table 4: root fresh weigt under the slab (g fresh)

	treatment					
	glasswool	rockwool	glassw. small pores		glassw. big pores	
cultivar	7.5 CM	7.5 CM	wet	dry	wet	dry
Nova	123.8	199.0	181.5	251.9	282.7	288.2
Video	263.5	257.2	381.5	414.5	391.5	394.7
average	193.6	228.1	281.5	333.2	337.1	341.5
group	cd	d	bc	ab	a	a

table 5: estimated rooted volume of each plant, dispersion of the roots, slab height and durability of the substrates

	treatment					
	glasswool	rockwool	glassw. small pores		glassw. big pores	
cultivar	7.5 CM	7.5 CM	wet	dry	wet	dry
Nova (1)	1.07	0.59	0.69	0.68	0.47	0.45
Video(1)	0.68	0.51	0.51	0.47	0.33	0.33
average (1)	0.88 A	0.55 B	0.60 B	0.57 B	0.40 C	0.39 C
surface						
Nova (cm^2)	169	100	151	148	110	104
Video(cm^2)	115	86	119	109	82	78
average(cm^2)	142 A	93 B	135 A	128 A	96 B	91 B
height						
Nova (cm)	6.4	5.9	4.6	4.6	4.4	4.4
Video (cm)	6.0	5.9	4.3	4.3	4.1	4.3
average(cm)	6.2	5.9	4.4	4.4	4.2	4.4
decrease'						
Nova (%)	15	21	8	9	13	12
Video (%)	21	21	14	15	18	13
average (%)	18 C	21 C	11 A	12 A	15 BC	13 AB

'decrease in percents of the initial height

table 6: number of main roots at the surface at 2.5 cm under the pot

	treatment					
	glasswool	rockwool	glassw. small pores		glassw. big pores	
cultivar	7.5 CM	7.5 CM	wet	dry	wet	dry
Nova	76.6	91.6	86.1	82.1	102.0	105.3
Video	99.4	97.0	97.5	110.5	96.3	99.1
average	88.0	94.3	91.8	96.3	99.1	101.2

Appendix E

table 7: number of flowers of quality 1/m^2.'

Culti-var	period	treatment rockwool 7.5 CM	glasswool 7.5 CM	glassw. small pores wet	glassw. small pores dry	glassw. big pores wet	glassw. big pores dry
NOVA	31-36	8.8 AB	9.5 AB	10.1 A	11.7 A	9.0 AB	7.2 B
	37-44	30.2 A	29.6 AB	28.5 ABC	25.0 C	28.9 AB	26.5 BC
	45-53	23.8	24.9	23.9	22.7	23.2	23.2
	1- 4	3.6	4.5	3.6	3.0	3.1	4.1
	5- 8	9.2	8.5	7.3	8.8	8.1	7.3
	9-12	13.3	13.5	11.3	12.9	12.8	11.3
	13-16	26.0 A	23.6 AB	21.8 B	21.0 B	22.8 AB	21.3 B
	17-20	30.2 A	29.6 AB	26.4 BC	24.6 C	27.4 ABC	25.7 C
	21-22	15.1 A	15.0 AB	14.2 AB	13.0 AB	14.3 AB	12.9 B
	31-53	62.8 AB	63.9 A	62.5 AB	59.4 AB	61.1 AB	56.9 B
	1-22	97.3 A	94.2 B	84.0 B	84.5 B	90.2 B	85.2 B
	92/93	160.0 A	158.1 AB	146.5 BC	143.8 BC	151.2 ABC	142.1 C
VIDEO	31-36	21.3 A	18.8 AB	21.5 A	18.3 B	15.3 C	19.7 AB
	37-44	46.3 A	42.0 B	39.2 BC	37.7 C	36.9 C	40.0 BC
	45-53	26.4	24.6	22.7	22.3	22.4	22.8
	1- 4	4.4	3.3	3.3	4.2	3.9	3.4
	5- 8	13.7 A	13.2 A	12.2 AB	10.6 B	11.9 AB	11.7 AB
	9-12	25.8 A	22.1 B	22.8 AB	20.9 B	19.6 B	22.2 B
	13-16	34.3 A	27.1 B	25.6 B	27.8 B	26.0 B	27.0 B
	17-20	37.2 A	32.1 B	30.7 B	31.0 B	28.6 B	31.1 B
	21-22	20.0 A	16.1 BC	16.9 BC	15.9 BC	14.8 C	17.1 B
	31-53	94.0 A	85.4 B	83.4 BC	78.2 CD	74.6 D	82.5 BC
	1-22	136.1 A	115.2 B	113.8 B	112.8 B	106.0 B	113.1 B
	92/93	230.1 A	200.6 B	197.3 B	191.0 BC	180.6 C	195.5 B
MEAN	31-36	15.1 AB	14.2 AB	15.8 A	15.0 AB	12.1 C	13.5 BC
	37-44	38.3 A	35.8 AB	33.9 BC	31.3 C	32.9 C	33.2 BC
	45-53	25.1	24.8	23.3	22.5	22.8	23.0
	1- 4	4.0	3.9	3.5	3.6	3.5	3.7
	5- 8	11.5 A	10.8 AB	9.8 B	9.7 B	10.0 AB	9.5 B
	9-12	19.5 A	17.8 AB	17.1 B	16.9 B	16.2 B	16.7 B
	13-16	30.2 A	25.3 B	23.7 B	24.4 B	24.4 B	24.2 B
	17-20	33.7 A	30.9 B	28.6 BC	27.8 C	28.0 C	28.4 C
	21-22	17.5 A	15.5 B	15.5 B	14.4 B	14.5 B	15.0 B
	31-53	78.4 A	74.7 AB	73.0 BC	68.8 CD	67.9 D	69.7 CD
	1-22	116.7 A	104.7 B	98.9 B	98.6 B	98.1 B	99.1 B
	92/93	195.1 A	179.4 B	171.9 BC	167.4 C	165.9 C	168.8 C

' The letters in the figures and the tables correspond with the statistical groups. When the treatments have the same character they do not differ significantly.

table 8: weight of the first quality flowers/m^2.'

Culti-var	period	treatment rockwool 7.5 CM	glasswool 7.5 CM	glassw.small pores wet	glassw.small pores dry	glassw. big pores wet	glassw. big pores dry
NOVA	31-36	257 A	247 A	257 A	297 A	224 AB	164 B
	37-44	771 A	754 A	729 AB	651 B	764 A	701 AB
	45-53	524	549	516	503	535	526
	1- 4	68	86	69	60	63	83
	5- 8	182	176	149	184	168	159
	9-12	308	314	255	300	310	272
	13-16	717 A	660 AB	559 C	552 C	626 BC	601 BC
	17-20	917 A	910 AB	753 C	718 C	802 BC	757 C
	21-22	435 B	453 B	377 CDE	361 E	405 BCDE	375 DE
	31-53	1552 A	1549 A	1502 AB	1451 AB	1523 AB	1390 B
	1-22	2640 A	2578 AB	2198 C	2259 C	2430 ABC	2334 BC
	92/93	4192 A	4127 A	3700 B	3709 B	3954 AB	3725 B
VIDEO	31-36	499 AB	467 AB	510 A	424 BC	368 C	447 ABC
	37-44	1241 A	1169 A	1082 BC	1009 BC	1041 C	1128 AB
	45-53	615	598	524	495	531	530
	1- 4	82	65	62	77	73	65
	5- 8	281 A	273 AB	249 ABC	213 C	248 ABC	235 BC
	9-12	578 A	498 B	498 B	476 B	449 B	510 AB
	13-16	898 A	708 B	661 B	694 B	667 B	695 B
	17-20	1085 A	905 B	846 B	851 B	792 B	823 B
	21-22	563 A	433 B	450 B	422 B	396 B	435 B
	31-53	2354 A	2234 AB	2116 B	1928 C	1941 C	2104 B
	1-22	3581 A	2980 B	2889 B	2860 B	2715 B	2851 B
	92/93	5935 A	5213 B	5005 BC	4788 C	4656 C	4955 BC
MEAN	31-36	378 A	357 AB	384 A	360 AB	296 C	305 BC
	37-44	1006 A	961 AB	906 B	830 C	903 B	914 B
	45-53	569 A	574 A	520 AB	499 B	533 AB	528 AB
	1- 4	75	75	65	69	68	74
	5- 8	231 A	225 AB	199 B	199 B	208 AB	197 B
	9-12	443 A	406 AB	377 B	388 B	379 B	391 AB
	13-16	807 A	684 B	610 B	623 B	647 B	648 B
	17-20	1001 A	907 B	799 C	785 C	797 C	790 C
	21-22	499 A	443 B	413 BC	391 C	401 C	405 BC
	31-53	1953 A	1891 AB	1809 BC	1689 D	1732 CD	1747 CD
	1-22	3111 A	2779 B	2544 C	2559 C	2573 BC	2593 BC
	92/93	5064 A	4670 B	4353 C	4249 C	4305 C	4340 C

' The letters in the figures and the tables correspond with the statistical groups. When the treatments have the same character they do not differ significantly.

table 9: mean weight of the flowers (g)

description	treatment rockwool 7.5 CM	glasswool 7.5 CM	glassw. small pores wet	glassw. small pores dry	glassw. big pores wet	glassw. big pores dry
Nova	26.2	26.1	25.2	25.8	26.1	26.2
Video	25.8	26.0	25.4	25.0	25.8	25.3
average	26.0 A	26.0 A	25.3 C	25.4 BC	26.0 AB	25.8 ABC

table 10: total number of flowers/m^2 and distribution of the quality in the period 1992-1993.

description	treatment rockwool 7.5 CM	glasswool 7.5 CM	glassw. small pores wet	glassw. small pores dry	glassw. big pores wet	glassw. big pores dry
NOVA						
total (number)	180.9	173.1	161.6	160.6	168.0	160.9
class 1 (%)	88.5	91.4	90.8	89.5	90.0	88.3
class 2 (%)	10.1	7.2	8.0	9.2	9.1	9.9
winterflowers(%)	1.4	1.4	1.2	1.3	0.9	1.8
VIDEO						
total (number)	251.7	216.9	213.7	208.8	195.2	210.5
class 1 (%)	91.4	92.5	92.4	91.5	92.5	92.9
class 2 (%)	8.4	7.3	7.6	8.5	7.3	7.0
winterflowers(%)	0.2	0.2	0.0	0.0	0.2	0.1

table 11: total weight of flowers/m^2 and distribution of the quality classes in the period 1992-1993.

description	treatment rockwool 7.5 CM	glasswool 7.5 CM	glassw. small pores wet	glassw. small pores dry	glassw. big pores wet	glassw. big pores dry
NOVA						
total (g)	4528	4364	3938	3972	4230	4031
class 1 (%)	92.6	94.6	94.0	93.3	93.4	92.4
class 2 (%)	6.8	4.8	5.5	6.1	6.1	6.8
winterflowers(%)	0.6	0.6	0.5	0.6	0.5	0.8
VIDEO						
total (weight)	6313	5502	5337	5104	4899	5214
class 1 (%)	94.0	94.8	93.8	93.8	95.0	95.0
class 2 (%)	5.9	5.1	6.2	6.2	4.9	4.9
winterflowers(%)	0.1	0.1	0.0	0.0	0.1	0.1

table 12: fresh weight of the plant (june 1993)

description	treatment rockwool 7.5 CM	glasswool 7.5 CM	glassw. small pores wet	glassw. small pores dry	glassw. big pores wet	glassw. big pores dry
NOVA	797	656	619	613	677	660
VIDEO	721	618	585	582	542	539
AVERAGE	757 A	637 B	602 B	598 B	610 B	599 B

Appendix F: analyses of the nutrient solution

table 13: major elements in the nutrient solution of gerbera 'Nova' and 'Video'.

		nutrient (mmol/l)						
Cultivar	DATE	NH4	K	Ca	Mg	NO3	SO4	P
nova	21-07-92	0.1	5.1	4.0	1.9	14.3	2.2	0.7
	25-08-92	0.3	4.3	4.3	1.8	13.5	3.5	1.0
	15-09-92	0.1	2.7	3.9	1.4	8.7	3.5	1.1
	13-10-92	0.1	4.0	3.5	1.3	9.5	2.3	1.4
	3-11-92	0.1	5.0	2.9	1.1	10.2	2.1	1.1
	14-12-92	0.1	8.1	3.5	1.5	14.0	2.5	1.0
	26-01-93	0.1	7.0	3.2	1.5	12.8	1.9	0.9
	23-02-93	0.1	6.6	3.2	1.2	12.1	1.8	0.9
	18-03-93	0.1	5.2	3.7	1.3	11.9	1.9	1.0
	6-04-93	0.1	4.7	4.2	1.4	11.6	2.4	0.8
	20-04-93	0.1	4.0	4.1	1.5	11.4	2.3	0.7
	13-05-93	0.1	3.5	6.0	1.9	14.2	3.0	0.8
video	21-07-92	0.1	3.8	4.4	1.9	14.4	2.1	0.8
	25-08-92	0.3	1.1	6.1	1.8	13.3	3.8	0.7
	15-09-92	0.3	1.8	5.2	1.4	9.6	3.8	0.7
	13-10-92	0.1	1.9	4.1	1.3	7.8	2.7	0.8
	3-11-92	0.1	1.9	3.7	1.3	9.1	3.0	0.7
	14-12-92	0.1	4.0	4.2	1.9	13.4	3.0	0.6
	26-01-93	0.1	5.0	3.5	1.6	13.5	2.0	0.6
	23-02-93	0.1	5.2	2.8	1.2	10.2	1.7	0.7
	18-03-93	0.1	3.6	2.7	1.1	10.0	1.6	1.0
	6-04-93	0.1	4.0	2.9	1.3	9.9	2.0	0.8
	20-04-93	0.1	4.8	3.0	1.5	10.9	2.2	0.7
	13-05-93	0.1	6.5	5.0	2.2	16.7	2.8	0.7

table 14: concentration of the minor elements in the nutrient solution of gerbera 'Nova' and 'Video'.

		nutrient (micromol/l)				
	date	Fe	Mn	Zn	B	Cu
nova	21-07-92	21.7	1.9	4.8	41.3	0.9
	25-08-92	44.0	3.4	5.6	82.0	1.9
	15-09-92	47.7	4.1	4.6	76.0	3.7
	13-10-92	39.0	3.8	3.8	37.0	1.2
	3-11-92	33.0	14.9	4.3	36.7	1.2
	14-12-92	39.7	11.3	5.4	35.0	1.2
	26-01-93	33.7	2.5	6.0	44.3	0.7
	23-02-93	33.3	1.4	7.5	36.0	1.0
	18-03-93	42.0	1.9	13.0	48.0	1.5
	6-04-93	32.7	1.2	14.0	43.0	1.2
	20-04-93	33.0	1.9	14.0	55.0	1.2
	13-05-93	46.3	5.4	15.3	37.3	2.6
video	21-07-92	22.7	2.7	5.0	43.3	1.0
	25-08-92	48.0	3.2	5.8	91.0	3.2
	15-09-92	49.3	3.9	6.0	87.3	2.3
	13-10-92	45.0	2.3	5.3	43.0	1.8
	3-11-92	40.0	1.3	5.2	39.0	1.7
	14-12-92	42.7	2.6	5.2	43.3	1.5
	26-01-93	35.0	1.7	5.3	50.0	1.0
	23-02-93	36.0	1.6	5.8	38.0	1.0
	18-03-93	37.0	2.1	11.0	62.0	1.7
	6-04-93	31.0	1.4	10.6	52.3	1.6
	20-04-93	30.0	1.3	9.5	61.0	1.5
	13-05-93	48.3	4.2	11.3	48.7	2.5

table 15: pH ,EC and HCO_3 of the nutrient solution of gerbera 'Nova' and 'Video'

	date	EC (mS/cm^2)	pH	HCO_3 (mmol/l)
nova	21-07-92	2.3	6.5	0.1
	25-08-92	2.4	6.1	0.1
	15-09-92	2.0	5.0	0.1
	13-10-92	1.8	4.4	0.1
	3-11-92	1.8	4.2	0.1
	14-12-92	2.2	4.5	0.1
	26-01-93	2.1	5.4	0.1
	23-02-93	1.9	6.3	0.1
	18-03-93	2.0	7.1	0.3
	6-04-93	2.0	7.0	0.3
	20-04-93	2.0	6.6	0.2
	13-05-93	2.4	4.7	0.1
video	21-07-92	2.2	6.2	0.1
	25-08-92	2.2	6.1	0.1
	15-09-92	2.2	5.7	0.1
	13-10-92	1.6	6.4	0.2
	3-11-92	1.8	6.3	0.1
	14-12-92	2.1	5.9	0.1
	26-01-93	2.2	5.9	0.1
	23-02-93	1.7	6.1	0.1
	18-03-93	1.6	6.5	0.1
	6-04-93	1.8	6.7	0.2
	20-04-93	1.9	6.6	0.2
	13-05-93	2.7	6.0	0.1