Postharvest Quality of Roses as Related to Preharvest Conditions

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Abstract

A nursery comparison with four different rose varieties was carried out as a follow-up from a previous comparison with one variety. Some of these four rose varieties reacted in the same way to a parameter related to plant growth, but there were also exceptions. A high relative humidity was correlated with a shorter vase life in 'Bianca', but a longer life in 'Red Berlin'roses. A high light level was positively correlated with vase life, in all varieties. A higher temperature corresponded with a longer vase life in 'First Red' but a shorter vase life in 'Bianca'. A greenhouse experiment in which three varieties were grown at various vapour pressure deficits (VPD) showed that the higher the VPD (the dryer the air) the longer the vase life. The transpiration rate of the cut rose stem during the first day of vase life correlated well (negatively) with the length of vase life. We observed crispy (desiccated) leaves in many of the roses, as the experiment was done during winter. We checked the effects of the osmotic value of the vase solution on the number of desiccated leaves. In deionised water the problem was the least, but here also some leaves became eventually crispy, indicating that the rate of water uptake was unable to compensate for the very high rate of transpiration.

INTRODUCTION

Rose growers will usually try to choose the greenhouse climate conditions that are optimal for growth, production, externally visible quality parameters like the length and thickness of the stems and the size of the flower buds. Postharvest quality does not always feature as a priority in these choices. Continuous supplemental lighting (24 hours per day) is an example of a measure which influences growth of roses positively, but can have a very negative effect on the length of vase life because the stomata do not close in the dark period, leading to excessive transpiration. A low rate of ventilation in the greenhouse, in order to keep the warm air inside, results in high relative humidity and causes a high transpiration rate during vase life (Mortensen & Fjeld, 1995, 1998).

Since the buyers of the product now often ask vase life guarantees, the growers need to know which preharvest conditions have a clear influence on postharvest quality.

A detailed nursery comparison is a good method to investigate the influence of a multitude of growth factors and their interactions. Such a nursery comparison provides the growers with tools to actively improve the postharvest quality of their product. It also allows them to estimate the length of vase life, based on the growth conditions prior to harvest. These studies can single out important factors and thus be used to design further work on the effect of such single factors on post-harvest quality.

Thus far it was unclear if the conclusions found for one variety were also valid for other varieties. In the winter of 1998 – 1999 a first nursery comparison was carried out for rose (Marissen & Benninga, 2001) with 35 nurseries growing the variety 'First Red'. In the winter 2000 – 2001 a follow up was carried out with four varieties, with ten nurseries per variety. This was done in order to see whether the results found for 'First Red' would be corroborated in another year, and in order to test if other varieties would react the same.

In the winter of 2001 – 2002 we also investigated the effects of relative humidity in the greenhouse on post-harvest quality of three rose varieties, in order to determine the threshold values for relative-humidity effects on vase life. This could be used as an advisory tool for the growers, especially in winter, when relative humidity tends to be high in the greenhouses. In winter the occurrence of desiccated ‘crispy’ leaves is a serious postharvest quality problem. Often, the problem is not yet seen during transportation, but will appear when the product has reached the consumers, or even sometimes when it is still at the wholesalers. The use of additives in the water during the transport chain seems to aggravate the problem, and so do vase solutions containing sugars. Markhart and Harper (1995) described the problem and showed that the detrimental effects of sugars in the vase solution is caused by plasmolysis of the leaf cells, caused by an increase of the osmotic value in the intercellular space. Due to the high transpiration by the leaves the concentration of the chemicals in the intercellular space increases and causes plasmolysis. The growers tend to decrease the concentration of pre-treatment chemicals, in order to avoid this problem, but sometimes even without any pre-treatment (thus in tap water only) crispy leaves occur. We did some small-scale tests on the occurrence of crispy leaves, in relation to the type of vase solution.

MATERIALS AND METHODS

Nursery Comparison

The nursery comparison was carried out as described before (Marissen and Benninga, 2001). A few alterations were made: four instead of one variety were used, ‘First Red’, ‘Sacha’, ‘Red Berlin’ and ‘Bianca’, with 10 growers per variety. Data were collected for 12 weeks, from week 42 in 2000, divided in three periods of four weeks, each period ended with the harvest of 20 stems for a postharvest test, and 10 more stems for mineral analysis of the leaves, and the ‘leaf drying test’ (LDT). This test, as described by Mortensen & Gislerod (1999) was slightly modified (1 and 2 hours of drying time, instead of three hours) and was included as a determination that has a good correlation with the transpiration rate during vase life. An excised leaf was left in a room of 20 °C, 35% RH and 13.8 µmol/m^2 s light from fluorescent tubes, and weighed after one and two hours in order to determine the weight loss as a percentage of the initial fresh weight. From a defined area in the greenhouse the number and total weight of the stems was recorded during the experimental period. Vase life was tested under standard circumstances, without a transport simulation.

Data were analysed with multivariate techniques (factor analysis, multiple regression and path analysis), as described before (Marissen and Benninga, 2001).

Greenhouse Experiment

In four greenhouse compartments three rose varieties were planted: ‘First Red’, ‘Orange Unique’ and ‘Vendela’. Planting date was October 2000. In three compartments air humidifiers were installed, and the relative humidity (RH) was set at 65, 77.5 and 85 %. From August 2001 until March 2002 regular postharvest tests were performed, in which vase life, transpiration, occurrence of crispy leaves, LDT and bud opening were measured. Transpiration rate was measured by weighing vase and stems, determining the leaf area and calculating the transpiration as ml water transpired per 100 cm^2 leaf area per 24 hours. Crispy leaf occurrence was classified as 0 = no damage, 1 = one leaflet with small spots, 2 = several leaflets with spots of minimal 0.5 cm, 3 = all leaflets with large spots to completely dry leaves.

Crispy Leaves as Dependent on Vase Solution

Osmotic values of the vase solutions were measured with a Gonotec cryoscopy osmometer, using 300 µl solution per measurement. Crispy leaf damage was classified as described above.

RESULTS AND DISCUSSION

Nursery Comparison

Table 1 shows the vase life for each variety, dependent on the nursery. ‘Sacha’ showed the largest difference between the best and the worst nursery (the fist and second harvest). At the third harvest the differences were smaller, in all varieties. A Spearman rank-correlation test showed that only ‘Red Berlin’ showed consistency in nursery performance: a nursery scoring a long vase life for the first harvest also scored high for the other harvests. In the other three varieties no such consistency was found. Yet, three nurseries scored a vase life of more than 12 days at each harvest, and 7 and 11 nurseries scored a vase life of 11 and 10 days, respectively. This is, with regard to vase life guarantees, more important than ‘having the best vase life’ all the time (Table 2).

The data were analysed in two ways: using the data of all four varieties in one dataset per harvest, or using the data of all three harvests in one dataset per variety.

1. Data per Harvest. At the first harvest 37 % of the differences in vase life could be explained by the factors RH (8%), production (9%), mean light level (10%), and the LDT (10%). This is not a very high explanation in comparison with the first nursery comparison, but it shows that even for four different varieties differences in vase life can be explained to a certain level. A high RH coincided with shorter vase life, a high production during the two weeks prior to the harvest correlated with a longer vase life, a high mean light level during the two weeks prior to harvest gave a longer vase life and a high percentage of weight loss in the LDT coincided with a shorter vase life.

At the second harvest hardly any explanation of the differences could be found. Nonetheless, when analysing the data it appeared that the biggest differences between the best and worst vase life of the four varieties were seen in this harvest.

At the third harvest 32% of the differences in vase life could be explained. The LDT explained 12 % (high weight loss, short vase life) of the differences. The mean light level and temperature of two weeks prior to harvest each explained 10% of the differences (high light level and low temperature gave a better vase life).

With regard to flower bud opening (determined at the end of vase life), 37%, 22% and 32% of the differences were explained at the three respective harvests. In the second and third harvest the bud stage at harvest explained bud opening for 7% and 12% respectively (a riper harvesting stage gave better opening during vase life). Other factors that were positively correlated with the final bud stage: mean light level, production, RH, temperature and age of the crop. Stem length correlated negatively with bud opening.

2. Data per Variety. Combining the data of the three harvests into one dataset per variety gave the opportunity to see if the three varieties all reacted on the same growth circumstances, and in the same direction.

In ‘First Red’ temperature appeared to have the strongest impact on vase life (the lower the temperature, the shorter the vase life). Flower bud opening also was negatively influenced by low temperatures. In ‘Red Berlin’ a clear positive correlation was found between RH and vase life. A high RH was here related to a longer vase life, which is in contradiction with previous results with ‘First Red‘, where a higher RH was correlated with a shorter vase life. In the literature such a negative correlation between RH and vase life (as in ‘First Red’) has been described for some other rose varieties (Torre 1999), thus ‘Red Berlin’ seems an exception. The opposite trend between RH and vase life in ‘Red Berlin’, compared with the other cultivars tested, may be the cause for the low percentage explanation as described for the second harvest, where the data of all four varieties were combined. Besides RH, a high light level was positive for the vase life of ‘Red Berlin’. This variety has a specific post-harvest problem, which is called ‘petal browning’. This occurs in several other dark-red varieties. When the incidence of petal browning is tested against greenhouse conditions, a high mean light level, a low production level and quick bud development during the preharvest phase correlates with a low occurrence of the problem.

‘Bianca’ showed a negative correlation between RH and vase life: in the group of nurseries with a mean RH of 76% it had a vase life of 13 days, while in the group with a mean RH of 86% its vase life was 9 days. This trend is comparable with 'First Red'. However, the effect of temperature on the vase life of 'Bianca' was opposite to what was found for 'First Red': a higher mean temperature led to a shorter vase life in the latter.

In 'Sacha' roses the mean light level, measured as the number of minutes the light level was above 200 μmol/m^2.s, was positively correlated with vase life. Many 'Sacha' growers use supplemental lighting, which therefore can be expected to increase vase life. However, using this lighting without applying a dark period of at least 4 hours in the night leads to a decrease in flower bud opening during vase life: with a mean dark period of only 30 minutes buds opened only until the flowers were half-open. When using a dark period of four hours (as recommended) or more, the buds opened completely. These results thus show how our research can provide advice for improving quality: use supplemental lighting to increase vase life, but apply a dark period of at least four hours in order to preserve a good bud opening.

It is concluded the results of the first nursery comparison were corroborated only partially. The differences between the cultivars clearly showed that caution must be taken with combining different varieties in one dataset.

Greenhouse Experiment

In Fig. 1 the relation between the mean RH (during the two weeks prior to harvest) and vase life is shown for the three varieties used in this experiment. The data originate from vase life tests from August 2001 until February 2002. There is no clear relationship between the two parameters. However, as was seen in the previous section, there seems an effect of temperature on vase life. During the present vase life tests a broad range of temperatures was measured in the greenhouse, with a maximum of 37 °C and a minimum of 18 °C. All four compartments had about the same temperature but the RH was different. Fig. 2 shows the relation between vase life and temperature. This positive correlation probably means that vapour pressure deficit of the greenhouse air (VPD), the amount of water that can be added to air up to the saturation point, was a better measure to correlate with vase life. A high VPD correlates with a low RH, but it is independent of air temperature. Because we did not measure the leaf temperatures, the relation between air water vapour pressure (VPD) and vase life was calculated. Fig 3 shows a clear relationship between VPD and vase life: the lower the VPD, the shorter the vase life. The correlations had a R^2 of 0.48 and 0.23 for 'Orange Unique' and 'Bianca', respectively. A linear relationship gave the best fit for all three varieties, indicating that there is not a clear threshold value above which the growers should keep the VPD in order to avoid vase life problems.

Mortensen (2001) and Torre (1999) found that a high RH during growth resulted in high transpiration during vase life. A high RH during growth also generally resulted in high rate of transpiration. We now measured transpiration during the first 24 hours of vase life and correlated this with the vase life of flowers from the same lot. Fig. 4 shows the relationship. In 'Vendela' in particular the correlation is very strong. The LDT also showed a good correlation, both with transpiration and with vase life (data not shown). It seems that the causal relationship between transpiration and vase life is such that a transpiration can not be sufficiently compensated by water uptake, thus leading to a water deficit (water stress), which decreases vase life. Many of these flowers were discarded in the vase life tests because of loss of petal turgor, leading to strong colour fading and loss of proper floral shape. Another main reason for discarding the flowers was the occurrence of crispy leaves.

Crispy Leaves and Vase Solutions

We observed crispy leaves in the vase life tests of the experiments described in the previous section. In these tests the stems were held in tap water. Since growers report that the number of crispy leaves increases when using vase solutions, we checked the osmotic value of several vase solutions, concomitant with vase life and crispy leaf scores, in rose

‘Akito’. Table 3 shows the results for the third and seventh day of vase life. Using a standard preservative solution, leaf damage was already seen on the first day. On day 7 crispy leaves even occurred when using deionised water. This apparently shows that it is not only the increase of osmotically active chemicals in the intercellular spaces that causes crispy leaves, but probably also water loss from the leaves which is not adequately compensated by water uptake. A small experiment with one leaf per stem wrapped in plastic showed that after three days this wrapped leaf had not developed dry spots, while the other leaves on the stem exhibited many such dry spots. After unwrapping the covered leaf on day 3, it showed dry spots one day later.

GENERAL CONCLUSIONS

Little is yet quantitatively known about the effect of greenhouse conditions on postharvest quality. This means that it will be hard to aim for a specific length of vase life, not shorter than the guaranteed life, but also not much longer than that. Growers who can give vase life guarantees, and therefore aim for the high-quality segment in the market, have to go for ‘the best possible’. However, this may be better than the minimal demanded quality. To achieve the best they may use substantial amounts of energy, for example in order to decrease the humidity in their greenhouse. Optimising greenhouse conditions for the length of guaranteed vase life, requires more detailed quantitative knowledge about the influence of preharvest conditions on postharvest quality. Nursery comparisons as we now carried out seem to provide such information.

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Tables

Table 1. Mean vase life (days) of roses from ten nurseries. The best and the worst result out of this group of ten, and the difference between best and worst.

	best	worst	mean	difference
		first harvest (week 46, 2000)		
First Red	12.5	8.1	9.9	4.4
Red Berlin	12.8	7.9	9.9	4.9
Bianca	14.1	6.2	10.1	7.9
Sacha	14.7	4.6	8.4	10.1
		second harvest (week 50, 2000)		
First Red	13.1	7.3	10.6	5.8
Red Berlin	14.1	7.2	10.2	6.9
Bianca	15.5	6.1	11.4	9.4
Sacha	16.4	6.5	12.0	9.9
		third harvest (week 2, 2001)		
First Red	11.4	10.0	10.9	1.4
Red Berlin	13.8	7.9	10.9	5.9
Bianca	14.2	8.6	12.3	5.6
Sacha	15.9	11.3	13.5	4.6

Table 2. Frequency segmentation of the vase life (days) scores for all three harvests.

Minimum vase life	Number of nurseries				
	First Red	Red Berlin	Bianca	Sacha	Total
12	-	1	2	-	3
11	1	3	3	-	7
10	3	3	4	1	11
9	7	7	4	4	22

Table 3. Osmotic value of the vase solution (mOsmol/kg), vase life (days) and leaf damage on the third and seventh day of vase life.

Vase solution	Osmotic value	Vase life	Leaf damage	
			Day 3	Day 7
Deionised water	0	9.7	0.3	2.3
Tap water	11	7.4	0.7	2.9
Preservative	53	14.4	1.3	1.5

Figures

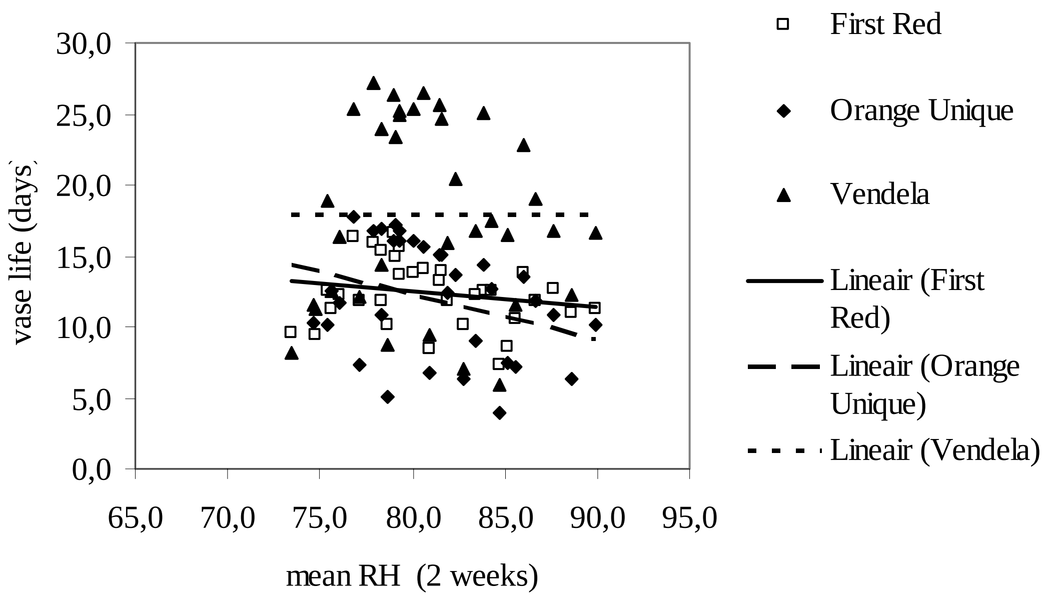

Fig. 1. Relation between vase life and mean Relative humidity (RH) in the greenhouse two weeks preceding harvest.

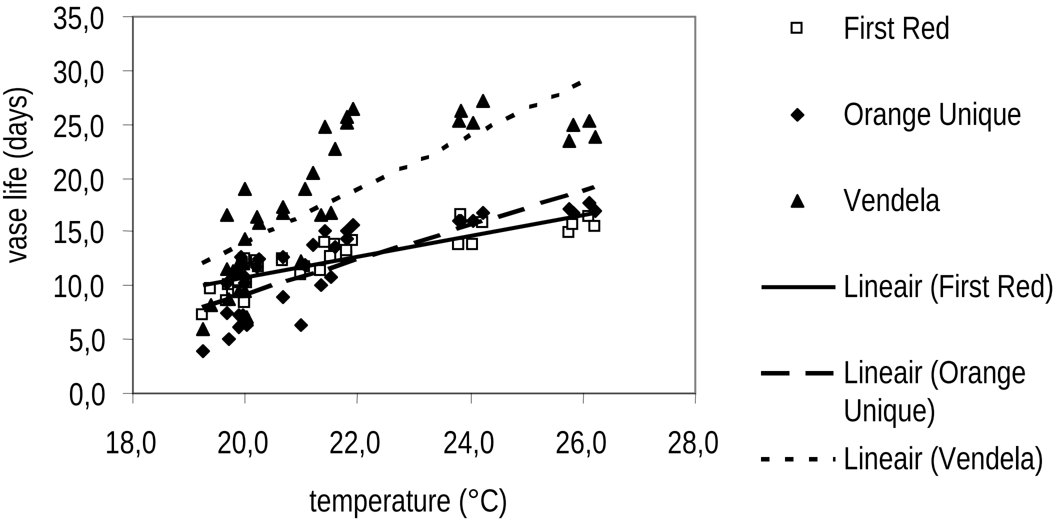

Fig. 2. Relation between vase life and mean temperature in the greenhouse two weeks preceding harvest.

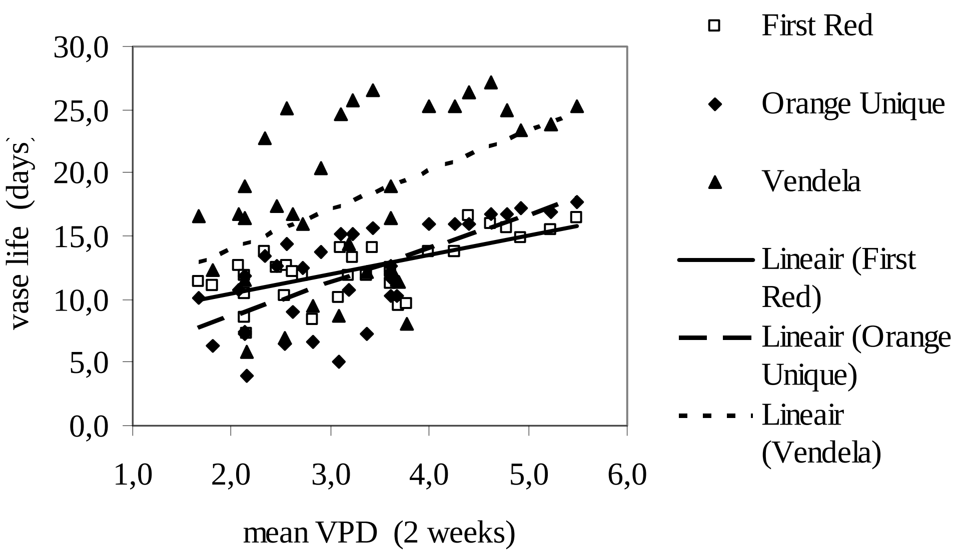

Fig. 3. Relation between vase life and Vapour Pressure Deficit of the greenhouse air (VPD) two weeks preceding harvest.

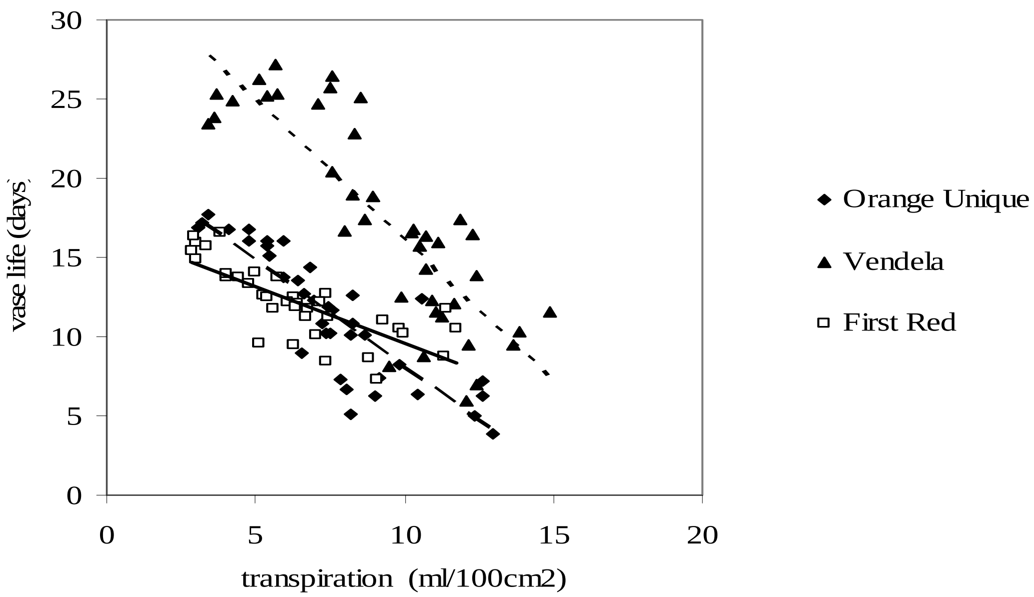

Fig. 4. Relation between vase life and transpiration (ml per 100 cm^2 leaf area) during the first 24 hours of vase life.