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GROWTH AND CATION ACCUMULATION IN SPRAY CARNATIONS

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ABSTRACT

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Spray carnations (*Dianthus caryophyllus* 'Exquisite'), planted as potted cuttings in December, had a maximum dry-matter production in summer of 22 g m^{-2} day^{-1}, calculated for the net surface area completely covered by the crop. This value is fairly similar to the maxima established for outdoor crops in The Netherlands.

The cation contents in the whole plant, expressed as percentages of dry matter, followed the series Na < Mg < Ca < K. They displayed no significant deviations from what was found in the literature for perpetual-flowering carnations. Growth was slow in the early phase of the crop and the cation accumulation was correspondingly slight. Growth increased at about 3 months after planting out. Over the period from March to September (24 weeks), the contents established in the aerial parts of the spray carnations amounted to 0.2 kg Na, 6.2 kg K, 2.9 kg Ca and 0.6 kg Mg per 100 m^2 gross.

INTRODUCTION

The spray-carnation crop has only become of economic importance during the past decade, which is probably the reason why very little is known about the growth of the crop and the quantitative accumulation of the most important cations. This kind of information is indispensable for the formulation of advice on the culture and mineral requirements of the crop.

It is true that investigations into these aspects have been carried out in perpetual-flowering carnations, but the question is whether the results are also valid for spray carnations. The main points studied were the yields, the growth measured as dry-matter production and the accumulation of Na, K, Ca and Mg.

MATERIALS AND METHODS

Rooted cuttings of cultivar 'Exquisite' were potted in 10 × 10-cm soil-blocks in mid-November 1973. The plant material was graded for uniform size at the end of the plant-raising period and the smallest plants were used for a separate project. Planting-out was done in the border soil of a heated glasshouse on 19 December 1973.

The treatments were: normal stopping with normal or hard cutting; light stopping with normal or hard cutting; small cuttings with normal stopping and cutting; and finally no stopping and no cutting. "Normal stopping" and "normal cutting" were done in the usual way. "Light stopping" included stopping-back to a smaller number of leaf pairs, and "hard cutting" meant cutting low to increase stem length of the marketable product.

The crop was planted in beds 1-m wide with plant density 24 plants per m^2 net. The plots were 6 m^2 in size and the experiment was not replicated. After 20 October 1974, the plot size was reduced to 3 m^2 per treatment. Plant samples for crop analyses were obtained from plots adjoining the actual experimental plots from which the yield data were collected. The plots were in the same bed and received the same treatments.

Crop analyses were carried out periodically on samples consisting of the aerial parts of a number of plants. Fresh matter, dry matter and the contents of Na, K, Ca and Mg were determined. Harvesting was carried out in the usual way, with the exception of the "no-cutting" treatment in which all the plant parts were left on the crop until the end of the experiment. The cut flowers were subjected to a quality assessment as well as a fresh-matter determination.

It was assumed that the flowers sent to auction had a dry-matter content of 16%, which was the average content determined on 30 May, just before the first pick. The mineral contents found at the end of May were also used as averages. The quantities of dry matter and minerals removed with the marketed flowers could be calculated with the aid of these data. It is unlikely that significant errors were made in the sampling at the beginning of September, firstly because no flower stems had been cut at the previous sampling in May 1974; secondly, because in September the weights of harvested flowers were less than half the weights of plants remaining in the glasshouse. The likelihood of errors in the results of May 1975 may have been slightly greater because of the longer period covered, although production was not very high during the period of September 1974 until the end of April 1975. It was shown that the values calculated for the first 5 treatments were not significantly different from the values determined for the last treatment.

RESULTS

The number of internodes and laterals of the first and second order give an impression of the structure of the plant. The data in Table I show that the height of stopping has in fact been too uniform considering the slight variations in the numbers of internodes. The stopping-height proved to have no effect on the number of laterals of the first order. Normal or hard cutting of the flower stems at harvest might have had some effect on the number of laterals of the second order, but this proved not to have been the case. Taken overall, the first treatments appeared to have had very little effect on the plant characteristics. The small cuttings did not produce remarkable differences compared with the previous treatments either. The only effect was found in the last treatment, which was left completely unpruned.

The first flowers were harvested on 4 June 1974. Taking into account that the experiment was not replicated, the treatments showed no great differences. In order to give an impression of the production, the yields of the treatments were averaged and the progress was plotted in Fig. 1. The quality was good during the first season. In winter, a lot of second quality flowers were harvested which caused an increase in the percentage of second quality flowers from 4% of the total yield at the end of January to 13% at the end of May. There were differences in fresh- and dry-matter production from treat-

TABLE I

Numbers of internodes of the main stems and the numbers of laterals of the first and second order averaged per plant

Treatment	Internodes	Laterals	
		First order	Second order
Normal stopping, normal cutting	5.4	4.7	15.7
Normal stopping, hard cutting	5.6	5.7	14.5
Light stopping, normal cutting	6.0	5.2	13.0
Light stopping, hard cutting	5.9	5.5	14.5
Small cuttings, normal stopping and cutting	5.7	5.2	11.5
No stopping, no cutting	13.0	11.7	20.2

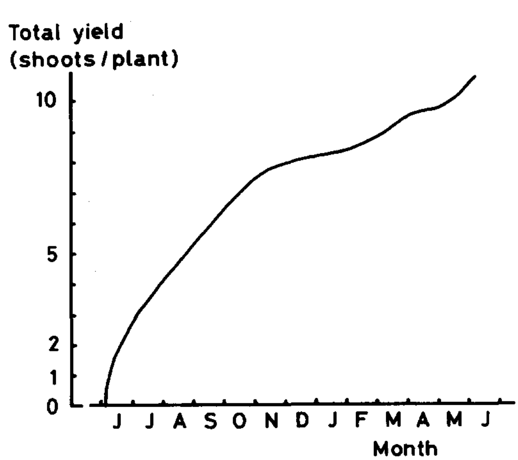

Fig. 1. Total yields averaged over the treatments.

ment to treatment within a certain sampling-date, but these were of secondary importance compared with the changes in time. In the context of these assessments, the effects of the treatments will therefore be ignored and attention will only be given to the averages for each date.

Table II shows that the production of matter takes place largely in spring and summer. The dry matter of the crop remaining in the glasshouse was mainly located in the stems, and this was increasingly so the case with the ageing of the crop. The quantities removed by September and by the following May amounted to about half the crop in situ.

TABLE II

Quantities of fresh and dry matter in g per plant averaged over the 6 treatments

Growing-period up to	Fresh matter total	Dry matter			
		Total	Stems	Leaves	Flowers
21 December 1973	7	0.9	0.2	0.7	
20 March 1974	30	4.8	1.2	3.6	
30 May 1974	304	50.6	23.6	21.9	5.1
2 September 1974	543	114	39	33	42
18 May 1975	852	169	63	41	65

The dry-matter contents of the crop, excluding stems harvested, on 21 December, 20 March, 30 May, 2 September and 18 May were 12, 16, 17, 22 and 21%, respectively, so this content showed an increase in the course of the season, reaching a maximum in September, after which it remained more or less constant.

The cation contents shown in Table III refer to the crop and may be described by the series Na < Mg < Ca < K. The Na, Ca and Mg contents were higher in a young crop than at a later stage, whilst the K content was, on average, not subject to great fluctuations as a result of age. The Ca and Mg contents were more predominant in the leaves than in the stems. This is also the case with Na, but to a smaller extent. Initially, the K content was lower in the leaves than in the stems, but the situation was reversed from September onwards. For the ratio between the content in the leaves and the corresponding content in the stems, the series was K < Na < Mg < Ca.

The accumulation of cations (Table IV) followed the series Na < Mg < Ca < K. The removal per plant was very small during the first phase of the crop until 20 March, after which the accumulation in the plant increased, reaching a maximum rate of uptake in summer. During the following period, including winter, the total accumulation increased less rapidly.

Table V shows the removal per unit of surface area. The calculations are based on a gross plant density of 17 plants per m^2 glasshouse surface area, excluding the main path.

TABLE III

Cation contents of the aerial parts of the crop expressed as percentages of dry matter

		Na	K	Ca	Mg
March 1974	Stems	0.10—0.18	4.04—5.03	0.72—0.94	0.28—0.35
	Leaves	0.15—0.18	3.29—4.06	1.74—3.16	0.67—0.72
	Weighted mean	0.17	3.87	1.90	0.60
May 1974	Stems	0.08—0.11	3.07—3.79	0.79—1.06	0.20—0.26
	Leaves	0.10—0.14	2.90—3.64	2.33—2.93	0.59—0.65
	Buds	0.01—0.04	1.53—2.15	0.80—1.21	0.20—0.24
	Weighted mean	0.09	3.49	1.66	0.39
September 1974	Stems	0.06—0.09	3.16—3.42	0.73—1.07	0.16—0.23
	Leaves	0.11—0.14	3.57—4.27	2.45—3.53	0.49—0.65
	Buds	0.02—0.08	2.03—2.98	0.73—1.05	0.18—0.22
	Weighted mean (not harvested)	0.09	3.53	1.69	0.34
May 1975	Stems	0.04—0.07	2.92—3.65	0.71—0.83	0.15—0.23
	Leaves	0.11—0.17	4.93—5.57	3.09—3.25	0.60—0.67
	Buds	0.01—0.07	1.71—3.27	0.80—1.05	0.26—0.31
	Weighted mean (not harvested)	0.09	3.99	1.66	0.37

TABLE IV

Cation accumulation averaged over the 6 treatments

Date	Weeks after planting	Accumulation (mg/plant)			
		Na	K	Ca	Mg
March	13	8	186	91	29
May	23	47	1782	845	199
September[1]	37	101	3795	1812	385
May[1]	74	145	6165	2666	613

[1] Including estimates of the flower stems harvested.

TABLE V

Removal of Na, K, Ca and Mg by spray carnations per 100 m^2 gross

Period	Number of weeks	Removal (kg/100 m^2)			
		Na	K	Ca	Mg
December—March	13	0.01	0.32	0.15	0.05
March—May	10	0.07	2.79	1.29	0.29
May—September	14	0.09	3.42	1.64	0.31
September—May	37	0.08	4.03	1.45	0.39

DISCUSSION

If rooted cuttings of spray carnations are planted out in a heated glasshouse in December, it will take a few months before a closed crop canopy is obtained. There is a second problem connected with the presence or absence of a closed crop canopy in glasshouse crops in general. Part of the surface area in a glasshouse is utilised not for plant growth but for paths. Depending on the crop, the area given over to paths and roadways may be quite substantial and may amount to more than 30% of the total surface area. The conversions from plants to m^2 bed carried out in this investigation were based on 24 plants per m^2 net, so that the closed crop canopy referred to the net area cropped excluding all paths and roadways. It may also be taken that the crop cover was complete by the end of March.

During the period from April until the end of August, when growth was strongest, average dry-matter production was 0.65 g $plant^{-1}$ day^{-1} or 16 g m^{-2} day^{-1} per net surface area. The maximum dry-matter production, taking place at the end of May, was estimated at 22 g m^{-2} day^{-1}. Alberda (1962) gives a dry-matter production for a closed crop of sugarbeet in The Netherlands of 20 g m^{-2} day^{-1} and for grassland a maximum production of 25 g m^{-2} day^{-1} in May, decreasing to 5 g m^{-2} day^{-1} in September. Sibma (1968) calculated growth rates of 16.2—22.8 g m^{-2} day^{-1} for 10 crops with closed canopies in The Netherlands during the summer period. A literature survey of high production rates observed in the field has been published by Loomis et al. (1971), who report 17 g m^{-2} day^{-1} as the lowest value for maize grown in The Netherlands, whilst the same crop in warmer regions is capable of reaching 52 g m^{-2} day^{-1}.

In my investigation, spray carnations showed a reasonable similarity with the crops mentioned, grown at the same latitude, but somewhat on the low side. The crops mentioned in the literature were all cultivated in the open field and little is known about the production rates under glass. An investigation by Spithost (1959) showed an average production rate over the whole season of 10 g m^{-2} day^{-1} for a late tomato crop grown in an unheated glasshouse, with a maximum value of 13 g m^{-2} day^{-1} in June. Compared with these values, the spray-carnation crop had a reasonable growth rate. However, in this comparison it should be taken into account that the tomato data referred to the number of plants per m^2 including the paths, so that one could not always assume a closed crop canopy. The values for the tomatoes require a correction upwards, but it is not known by how much. For crops under glass, the correction factors for a closed crop canopy used in the conversions from plants to surface area will have to be established experimentally for each case.

With regard to the production rates under glass generally, it might have been expected that these would have been higher than for crops in the open. It is remarkable that this did not prove to be the case. However, there are too few data available in this publication to draw firm conclusions. Taking into account also the quantitative effect of the decreased light transmission through the glasshouse roof, it would be interesting to carry out further research into this aspect.

The maximum Na content in the dry matter was 0.18%, found in the leaves of the young crop. This value was less than one-tenth the highest content, i.e. 2.2% Na, established by Green et al. (1971) in perpetual-flowering carnations. On the other hand, their lowest Na content was even lower than that found in my investigation. However, they used sharply fluctuating nutrient solutions, which may lead to the assumption that the perpetual-flowering carnation is apparently not very selective with regard to Na uptake. The question is whether this is also valid for spray carnations or whether the soil used in my experiment had a reasonably uniform, and not too high, Na content.

The average K content of the whole plant was more than 3%, which corresponds well with the results of Green et al. (1971) for the leaves of perpetual-flowering carnations at maximum dry-matter production. The highest values in both investigations did not vary a great deal, but the minimum values did. Green et al. found one-tenth as much K in the plants without K supply as I did. Overall, the K values recorded in the present investigation corresponded reasonably well with the K contents in perpetual-flowering carnations found by Lasala and Cardus (1974), El-Shafie (1977) and Khattab et al. (1977).

The Ca contents of the leaves were within the limits established by Green et al. (1971) for the leaves of perpetual-flowering carnations, although they were higher than the values found by Lasala and Cardus (1974), also in perpetual-flowering carnations. Apparently, the Ca accumulation in the carnation depends heavily on the Ca supply in the substrate.

The Mg content in the leaves amounted to an average of about 0.6%, which is also the value found by Green et al. (1971) in the leaves of perpetual-flowering carnations at maximum dry-matter production. Lasala and Cardus (1974) obtained lower Mg contents in the leaves of perpetual-flowering carnations, which could have been the result of the lack of Mg fertilisation of their substrates. A remarkable point with regard to the Mg content of the whole plant, was the reduction in the content in the course of the season. This was more the result of a decreasing Mg content in the stems of older plants than of a reduction of the Mg content in the leaves.

With regard to the mineral contents generally, the conclusion could be drawn that the spray carnation does not differ greatly from perpetual-flowering carnations. It was also shown in spray carnations that there were no great differences between the Na and K contents of the stems and the leaves. In contrast, much lower Ca and Mg contents were found in the stems than in the leaves, and this has also been established in tomatoes (Spithost 1959).

In comparing the removal data for various crops, the crop density and the growing-period should be taken into account. Table V was based on the usual plant density of 17 plants per m^2 gross, which means that the removal data refer to the bed area and the path area together. The growing-period is an important factor in glasshouse crops, which are often subject to multiple harvests with the result that the total period of time for the crop can be varied at will. This is why the total growing-period has been divided in Table V. The period from March until September consisted of 24 weeks and this period is suitable for comparisons with, for instance, a tomato crop. During this period, the spray carnation crop accumulated 0.2 kg Na, 6.2 kg K, 2.9 kg Ca and 0.6 kg Mg per 100 m^2 gross. For a late tomato crop in an unheated glasshouse, removal rates of 0.4 kg Na, 6.2 kg K, 4.9 kg Ca and 0.9 kg Mg were determined (Spithost, 1959). Hence, the K accumulation was the same but the Ca accumulation by the spray carnations was substantially less. The differences for Na and Mg were not great in the absolute sense, but the spray carnations accumulated relatively less of these elements in the crop as a result of the low levels. For tomatoes, on the basis of 260 plants per 100 m^2 over a period of 35 weeks, Velchev and Velcheva (1977) calculated a removal of 6.0 kg K, 1.7 kg Ca and 0.5 kg Mg, which is less than for spray carnations.

The overall conclusion is that in a period of strong growth, in this case starting at about 13 weeks after planting out, the accumulation of the most important cations in spray carnations is not much less than it is in a complete tomato crop in a cold glasshouse.

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