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Effects of Nitrogen and Potassium Nutrition on Flower Yield and Quality of the Glasshouse Rose Carol

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Summary

The effects of varying nitrogen and potassium applications to the rose *cv* Carol grown in pots were investigated in trials extending over two years. Increasing nitrogen increased flower yield and flower fresh weight but adversely affected intensity of colour. Keeping quality tended to improve with increasing N. Potassium did not affect flower yield, colour intensity or keeping quality but improved flower fresh weight. Optimum N content of leaves was 3·2—3·5%. Optimum potassium content was 2·05—2·30%. There was an important positive N × K interaction effect on flower fresh weight indicating the need to balance nitrogen applications with adequate potassium. A ratio ($N:K_2O$) of 1:1 is suggested for rose fertilizer.

Introduction

Glasshouse roses nowadays occupy the leading position in Dutch floriculture, covering, in 1970, 1,055 acres (427 ha) or 26% of the total floricultural area, the corresponding turnover being 116 million guilders or 26% of the total value for flower crops.

Applying both commercial fertilizers and farm yard manure to roses, using soil test data as a guide, has been common practice for some decades. However, the fertilizing standards used did not result from research work but from practical experience. Consequently, in spite of the wide use of fertilizers, no clear concept concerning the real objectives of that practice can be put forward as yet.

In fact, research on the nutrient requirements of roses is still in its initial stage, a situation not widely differing from that in other flower-growing countries. Of the few papers dealing with the nutrition of roses, emphasis has been largely on the response at deficiency levels of nutrients[1–6]. Little attention was paid in those papers to the influence of nutrients on flower quality.

Taking into account their greater economic importance it is surprising that nutritional research with roses is in a far less advanced stage than with carnations or chrysanthemums. Undoubtedly, this should be attributed to difficulties induced by both the much larger variability and the more complicated management of rose plants. Yet optimum use of fertilizers for making rose growing more profitable is an urgent matter in view of the high investments and the additional high costs of labour and energy.

Four years ago a programme of research on the nutrition of glasshouse roses was begun. This paper reports an investigation dealing with the effects of nitrogen and potassium on flower yield and quality of the pink floribunda variety Carol, one of the most widely grown roses in Dutch floriculture.

Materials and Methods

Experiments were carried on a sand-peat mixture in pots to study the effects of N and K on the flowering properties of roses. The investigation, lasting two years, included three trials.:—

Trial 1: six rates of nitrogen:—

1st year	0·56, 1·12, 2·24, 3·92, 6·16 and 8·96 g N per pot.
2nd year	0·7, 1·4, 2·8, 4·9, 7·7 and 11·2 g N per pot.

Trial 2: six rates of potassium:—

Potassium rates (as K_2O per pot) were the same as the nitrogen rates of Trial 1.

Trial 3: nitrogen and potassium in factorial experiments:—

1st year	Two N rates: 1·12 and 6·16 g N per pot. Two K rates: 0·56 and 6·16 g K_2O per pot.
2nd year	Two N rates: 1·4 and 7·7 g N per pot. Three K rates: 0·7, 7·7 and 14·7 g K_2O per pot.

All treatments were replicated eighteen times, except that in Trial 3, the number of replications was reduced from eighteen in the 1st year to twelve in the 2nd year.

In Trial 1 potassium was supplied at 6·16 g K_2O per pot in the 1st and 7·7 g K_2O per pot in the 2nd year.

In Trial 2 nitrogen was supplied at exactly the same rates as potassium in Trial 1.

In all three trials phosphorus was supplied at 4·48 g P_2O_5 per pot in the 1st and at 5·6 g P_2O_5 in the 2nd year.

Nitrogen, phosphorus and potassium were given as nitrochalk, triple superphosphate and potassium sulphate, respectively.

The mode of application was the following:—

1st year: half the fertilizer dressing incorporated in the soil mixture prior to planting, half as four split surface applications

2nd year: eight surface dressings applied at four weeks' intervals from February to October. Trace elements were added in ample amounts.

The pots contained 12·5 litres of a soil mixture consisting of 1 part by volume of coarse river sand, 3 parts of frozen decomposed sphagnum peat and 5 parts of ordinary sphagnum moss peat, limed with 5 g of dolomitic limestone per litre up to an initial pH (water) of 5·7.

Grafts of Carol on rootstock *Rosa canina* were set out in pots on February 6th, 1969. The pots were irrigated with tap water by means of the Danish Volmatic capillary system. The tension of the soil moisture in the pots was measured daily in the 2nd year using tensiometers; the average reading at 2 p.m. was about 35 cm water. According to the pF curve of this type of substrate the concomitant air content was 25% (v/v), indicating an adequate air supply to the roots.

Cultural practices were typical of those used for commercial glasshouse roses. Five periods of blooming occurred in the 1st year and six in the 2nd year.

All three trials were terminated on December 31st, 1970.

The observations included measurements of flower yield and flower fresh weight. Additionally, in the 2nd year, the intensity of the flower colour was rated in terms of the following scale: 1=very light; 2=light; 3=normal; 4=dark; 5=very dark.

Moreover, that year a standardised test of the keeping quality was performed using one marketable flower per replicate pot for each period of blooming.

Leaf samples were collected for analysis in the 2nd year on two occasions, viz. during the period of blooming in April and that from September 15th to October 15th. The samples consisted of the three uppermost five-leaflet leaves on the stem of a flower having just reached cutting maturity.

Results and Discussion

Trial 1

Fig. 1 shows the influence of nitrogen rate on flower yield, flower fresh weight and flower colour intensity.

Flower yield in both years increased markedly with nitrogen rate, even more so in the 2nd year, obviously due to greater plant vigour. This can also be held responsible for the much higher average yield. The optimum nitrogen rate was about 8 g N per pot in the 1st year. No such level was attained in the 2nd year, but by extrapolation the optimum nitrogen rate can be estimated at approximately 14 g N per pot.

Flower fresh weight in both years rose with nitrogen rate; again more rapidly in the 2nd year, at least in the lower range. The average flower fresh weight was much larger in the 2nd than in the 1st year, which again may be attributed to augmented plant vigour. In terms of flower fresh weight, the optimum nitrogen rate was about 10 g N per pot in the 1st year and about 11 g N per pot in the 2nd year, thus deviating somewhat from those for flower yield. No great accuracy, however, can be attached to these values due to the almost flat shape of the curves near the optimum.

As is generally known roses are graded according to the length of the stem. To evaluate flower fresh weight properly as a quality criterion, it has first to be converted into stem length, which can readily be performed by means of Table 1. This table shows (1) the relationship between flower fresh weight and range

Table 1—*Relationship between flower fresh weight, range of grade length and grade for the rose variety "Carol."*

Flower fresh weight, g	4·5	7·5	9·0	12·0
Grade length range, cm	22–29	29–36	36–43	>43
Grade	3	2	1	extra

of grade of the flower stem, derived from data from Steffen[6] for Carol; (2) the relationship between grade length of stem and grade, adopted for the grading of flowers of Carol in Aalsmeer.

Apparently, there is a close connection between flower fresh weight and grade. Since flower fresh weight responds favourably to nitrogen application, it can be inferred that proper use of nitrogen fertilizers in rose culture is most conducive to producing flowers of the highest grades. In fact, as Fig. 1 shows, increasing

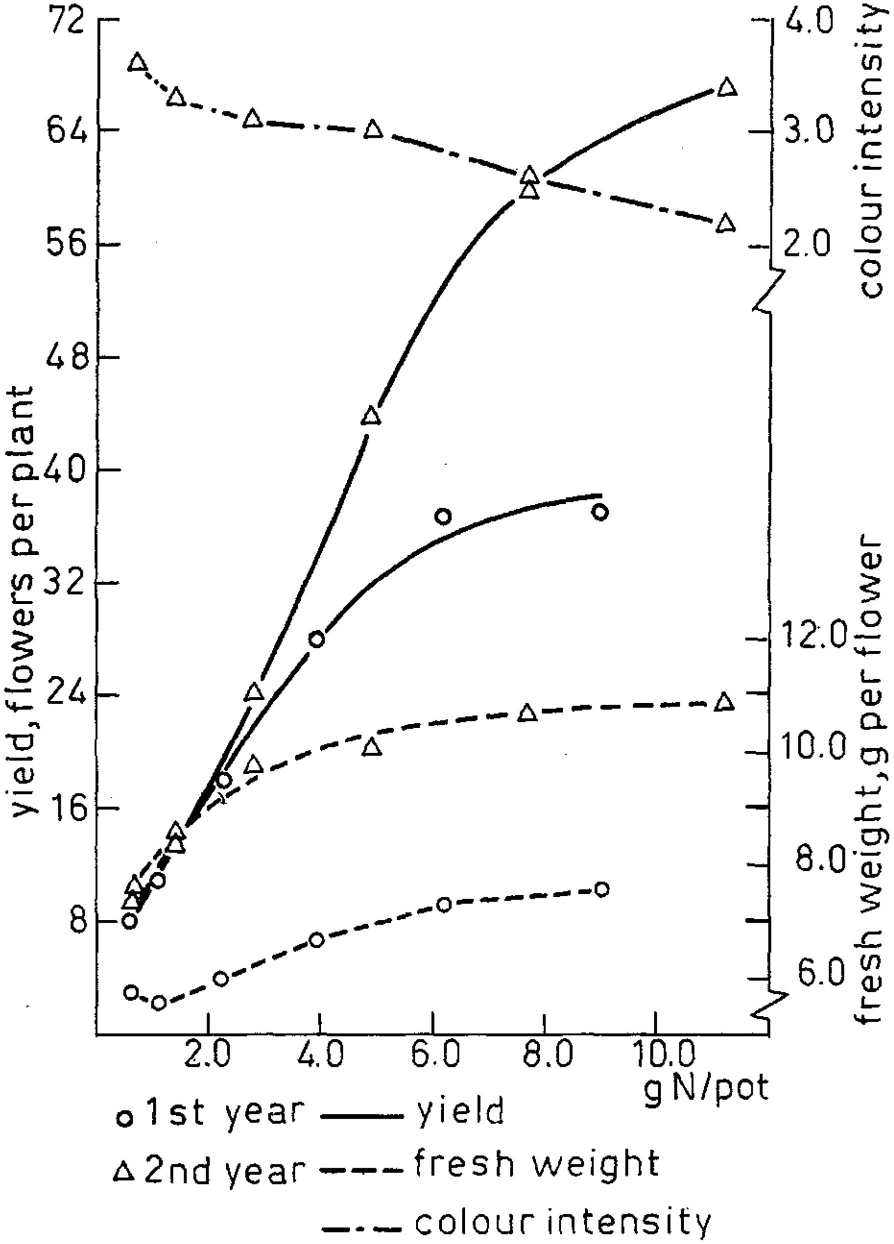

Fig. 1—Yield of flowers, fresh weight per flower and colour intensity of flower as affected by N-rate (N-linear significant at P=0·01 for all three plant properties)

nitrogen rate from the 5th to the 6th level in the 1st year raised flower quality from the 3rd to the 2nd grade while increasing nitrogen rate from the 3rd to the 4th level in the 2nd year raised flower quality from the 2nd to the 1st grade.

Flower colour intensity showed a slow but steady decline with increasing nitrogen rate. This result seems in contrast with those of Lindstrom and Markakis[7]. These authors, maintaining potassium at a high but constant level, found the red colour of Better Time roses turn darker with increasing nitrogen rates. It is possible that the anthocyanin causing the red colour in Better Time is different from the one causing the pink colour in Carol. No matter how this colour behaviour will eventually be explained the following conclusion seems justified: For Carol a deep pink flower colour is incompatible with a high nitrogen rate needed for best flower production.

The test on keeping quality showed the following results:—

g N per pot	0·7	1·4	2·8	4·9	7·7	11·2
Keeping life in days	10·8	11·2	11·6	11·7	11·7	11·5

Increasing nitrogen rates tended to improve keeping quality slightly.

Table 2 gives the nitrogen contents in leaves with increasing nitrogen rates. Nitrogen in leaves rose consistently with nitrogen rate, though, in view of the

Table 2—*Percentage of nitrogen in rose leaves with increasing nitrogen rates (2nd year)*

Date of sampling	g N/pot 0·7	1·4	2·8	4·9	7·7	11·2
April	2·10	2·28	2·57	3·04	3·17	3·15
Sept./Oct.	2·34	2·63	2·74	2·88	3·00	3·03

nitrogen rates supplied, the range obtained was less wide than expected, being even smaller at the 2nd sampling date. In terms of yield, optimum nitrogen in leaves might be estimated as lying between 3·2 and 3·5%, a somewhat lower value than that for Baccara, which was found to be 3·8%[8]. The estimate of the optimum for Carol coincides with the normal range of nitrogen in rose leaves given by Boodley and White[9], but lies far below the range mentioned by Oertli[1] for healthy rose leaves taken from Red Delight and Better Times.

Potassium in leaves varied from 2·17 to 2·57% in April and from 1·94 to 2·31% K in September/October showing in both instances a slow rise from the 1st up to the 3rd or 4th nitrogen level but a decline at still higher levels.

The average contents of other nutrients in leaves in April and September/October were: 0·45 and 0·37% P, 0·37 and 0·36% Mg and 1·66 and 1·40% Ca. These data do not give rise to any comment, except that the phosphorus contents are considered slightly excessive.

Trial 2

In Fig. 2 flower yield, flower fresh weight and flower colour intensity have been plotted against potassium rate.

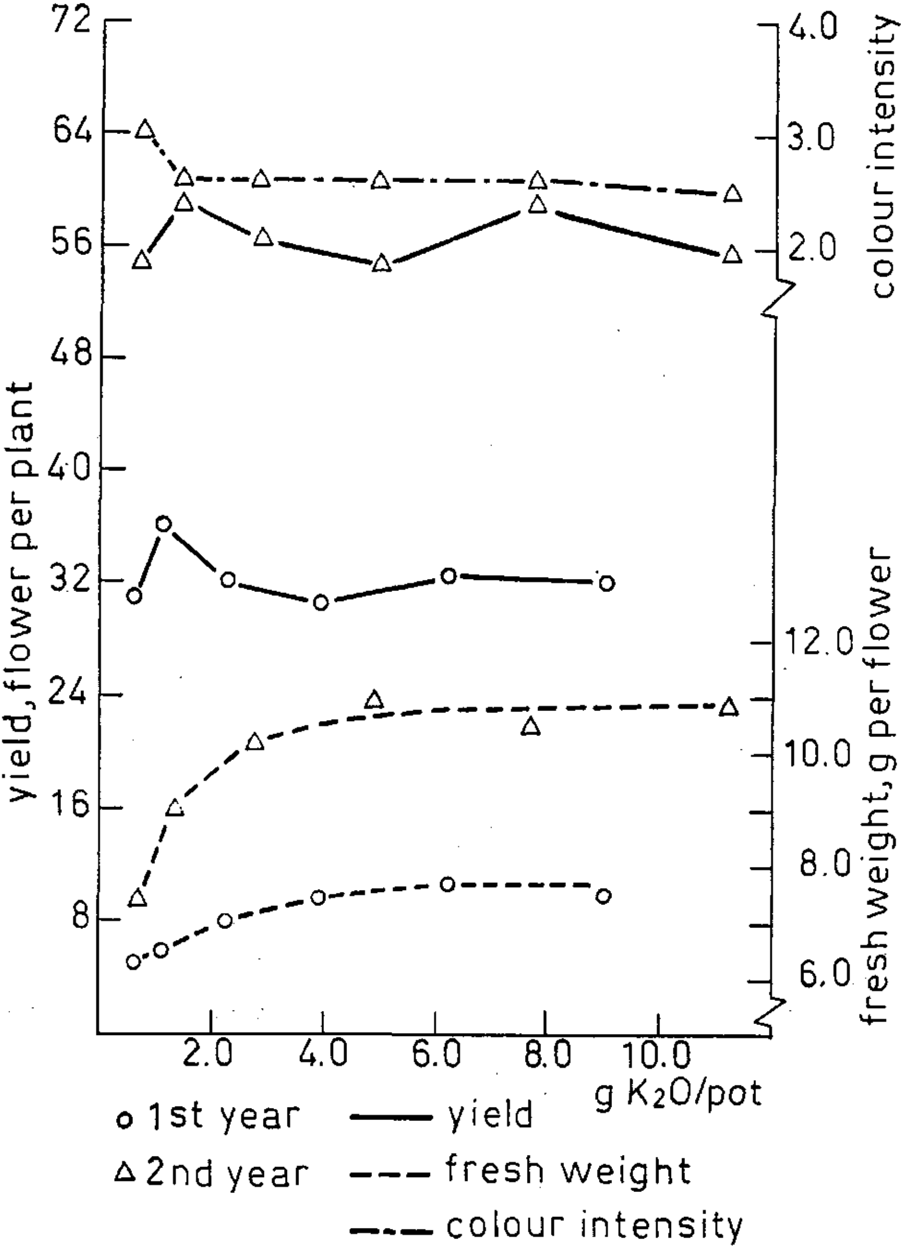

Fig. 2—Yield of flowers, fresh weight per flower and colour intensity of flower as affected by K-rate (K-linear significant at P=0·01 for flower fresh weight and colour intensity).

Neither curve relating yield and potassium rate gives evidence of potassium appreciably affecting flower yield.

On the other hand flower fresh weight, rising sharply with potassium rate in the lower range, appeared to depend largely on potassium supply.

As with nitrogen, the effect of potassium was clearly larger in the 2nd year, which is similarly to be ascribed to increased plant vigour. The optimum potassium rate was 6·2 g K_2O per pot in the 1st year, and in the range between 8 and 10 g K_2O per pot in the 2nd year. As in Trial 1, the average flower fresh weight was much larger in the 2nd than in the 1st year.

These results focus attention on the importance of adequate potassium supply in producing roses of the best grades, the marketing value of roses depending very much on grade. Using Table 1, it can be shown that flower quality in both years was raised from 2nd to 1st grade by increasing potassium rate from the 4th to the 5th rate in the 1st year and from the 1st to the 2nd rate in the 2nd year.

From the results in the 2nd year the impression is gained that the advantageous influence of nitrogen was somewhat superior to that of potassium.

A slightly adverse effect of potassium on flower colour intensity was noticeable.

The keeping life of roses, averaging 11·1 days, proved to be independent of potassium rates.

Table 3 gives the potassium content in leaves as affected by potassium rate. Potassium in leaves rose steadily with higher potassium applications and at a

Tabel 3—*Percentage of potassium in rose leaves with increasing potassium rates (2nd year)*

Date of sampling	g K_2O/pot 0·7	1·4	2·8	4·9	7·7	11·2
April	1·18	1·49	1·86	2·17	2·26	2·46
Sept./Oct.	1·25	1·32	1·70	1·99	2·03	2·09

greater rate than the increase of nitrogen in leaves induced by rising nitrogen rates. From the 2nd potassium rate upwards potassium in leaves was lower on the 2nd than on the 1st sampling date.

With respect to flower fresh weight optimum potassium in leaves might be estimated at 2·30 and 2·05% in April and September/October, respectively. These values fall in the normal range of potassium in rose leaves as given by Boodley and White[9].

As far as flower yield is concerned potassium in leaves might be allowed to fall as low as 1·18% without affecting yield performance appreciably.

Nitrogen in leaves was fairly constant at 3·1% with all potassium rates. The contents of the other nutrients in leaves were practically equal to those found in Trial 1.

Trial 3

The results of Trial 3, solely designed to assess the importance of any N × K-interaction, showed no interactions for either yield, flower colour intensity or keeping quality, but only the same main effects as those in trials 1 and 2 except that there was no effect at all of N on keeping quality.

Thus the sole remarkable feature of Trial 3 appeared to be the N × K interaction for flower fresh weight in both years, as is shown in Table 4. This interaction implies the following: Increasing either N or K supply at a low K

Table 4—*Flower fresh weight in g with N × K treatments in 1st and 2nd year*

g N/pot	g K_2O/pot 0·56	6·16	Mean
1st year*			
1·12	6·2	5·8	6·0
6·16	5·9	7·6	6·8
Mean	6·1	6·7	6·4

g N/pot	g K_2O/pot 0·7	7·7	14·7	Mean
2nd year**				
1·4	9·2	8·4	8·2	8·6
7·7	8·4	10·6	10·8	9·9
Mean	8·8	9·5	9·5	9·3

* N-effect (P=0·001); K-effect (P=0·01); N × K-interaction (P=0·001)
** N-effect (P=0·001); N × K-interaction (P=0·001).

or N rate, respectively, depressed flower fresh weight, whereas increasing either N or K supply at a sufficiently high K or N rate, respectively, raised flower fresh weight.

The foregoing results point to the necessity of providing roses with well-balanced N and K applications. Taking into account the rates of N and K which gave the largest flower fresh weights in all three trials it might be concluded that N and K_2O in the ratio 1:1, supplied at a sufficiently high level, are likely to render satisfactory flower fresh weights.

The typical response of flower fresh weight to N and K in Trial 3 may be elucidated, at least partly, by the K content in leaves, as shown in Table 5.

Table 5—*Percentage of K in rose leaves with N × K treatments in 2nd year*

g N/pot	April, g K_2O/pot 0·7	7·7	14·7	Sept./Oct., g K_2O/pot 0·7	7·7	14·7
1·4	2·04	2·30	2·40	1·88	2·31	2·35
7·7	1·33	2·20	2·40	1·04	2·02	2·11

Evidently, the decline in flower fresh weight brought about by increasing N at the lower K rates was parallelled by a reduction of K in leaves. This suggests that the actual cause of the decline of flower fresh weight was a deterioration of the K status of the plant attributable to a "dilution effect" resulting from the stimulated growth, which was induced by the increased N rate.

The decline of flower fresh weight, when K rate is increased at a low N rate cannot be similarly explained, the N contents of leaves exhibiting no effect of K at either N level.

The treatments of Trial 3 with the largest flower fresh weights produced a N content in leaves of 3·11 and 3·04%, and a K content in leaves of 2·40 and 2·11% on the 1st and 2nd sampling date, respectively. These contents agree reasonably well with the corresponding optimum values in trials 1 and 2.

REFERENCES

1 OERTLI, J. J. (1966). *Florist's Rev.* 138 (June 23): 21.
2 OERTLI, J. J. (1966). *Florist's Rev.* 138 (June 30): 17.
3 OERTLI, J. J. (1966). *Florist's Rev.* 138 (July 7): 37.
4 OERTLI, J. J. (1966). *Florist's Rev.* 138 (July 14): 20.
5 OERTLI, J. J. (1966). *Florist's Rev.* 138 (July 21): 35.
6 STEFFEN, L. (1969). Rosen unter Glas und Treibgehölze. *Verlag Eugen Ulmer, Stuttgart.*
7 LINDSTROM, R. S. & MARKAKIS, P. (1963). *Science* 142: 1663-1664.
8 ARNOLD BIK, R. (1970). *Vakbl. Bloemisterij* **25**: 478-479.
9 BOODLEY, J. W. & WHITE, J. W. (1969). Fertilization. In: J. W. Mastalerz & R. W. Langhans (Ed.), *Roses. N.Y. State Flower Growers Association, Inc.* 78-92.

Opening of Discussion

J. G. D. Lamb

Dr. Bik's comments on the importance of glasshouse roses in Holland emphasise the contrast with the situation here and in Britain, where little of the glasshouse area is under roses. The situation in Holland is a fore-runner of what is likely to happen here in the future, yet little research has been done, compared with the great amount of work carried out on, for example, tomatoes and cucumbers.

Dr. Bik's paper is of fundamental importance in rationalising ideas on the real objectives in fertilizing roses.

Now we have some fundamental information on the effects of nutrients on yield and quality of bloom. His findings on the effect of nitrogen on quality and life of bloom are very interesting and are logical in the context that in roses flower fresh weight and stem length are correlated, but are a salutary reminder to those more familiar with quality as measured in edible crops, where potassium is emphasised more. It is fortunate that we can grow larger rose blooms without having a big flower on a short stem.

Dr. Bik's fundamental concepts still have to be translated into commercial practice and immediately we come up against a number of further questions. What will be the influence of rootstock and cultivar?

He has already pointed out some difference between Carol and other cultivars in their reaction to treatments. The more research we do in plants the more distinct cultivars seem to be —whether we try to root them from cuttings, feed them, illuminate them or treat them in any other way. They appear more distinct, perhaps, than the botanists would be prepared to admit. It does seem that, if we really understood plant physiology, a lot of the *ad hoc* research work being done today could be short circuited.

Perhaps I may draw on experience with another woody plant, the apple tree, where we have found that standard annual dressings of fertilizers, particularly nitrogen, given by growers have resulted in a build up to excess levels through accumulation in the storage tissues of the trees. Would Dr. Bik tell us whether, with a crop like roses, where there are more or less continuous flushes of production, a similar situation could arise? This is assuming, of course, that the grower does not monitor the nutrient levels through periodic plant analysis. Would Dr. Bik anticipate modification of the fertilizer programme as the bushes grow old?

I would also like to ask Dr. Bik if his observations lead him to consider that there would be any advantage from altering the nitrogen: potassium ratio at different seasons of the year.

Dr. R. Arnold Bik.

In fertilizing roses in the Netherlands no influence of either cultivar or rootstock has so far been taken into account. This is partly because of lack of information on this matter and partly because there has been no need to pay special attention to it. On the other hand comparative trials have shown more or less large differences in growth between cultivars and rootstocks, suggesting the existence of a relationship between either factor and fertilization. It would seem worthwhile to conduct a trial to determine to what extent optimum nutrient levels depend upon either cultivar or rootstock.

As to the possibility of excessive salt levels in the plants resulting from continuous fertilizer supply, I do not think it is likely to happen in our conditions; first, because of the continuous harvesting of flowers alongside the formation of new shoots, and, second, because of the practice of controlling soil chemical conditions based on soil tests. Particular attention is paid to prevention of soil salinity since the irrigation water contains fairly high amounts of chloride.

I do not think the age of the crop to be very important in fertilizing roses except for the first six months after planting while the plants are establishing. The plants are hard pruned at the end of each year so that most of the aerial part is never more than one year old at most and thus is about the same age each season.

We recognise that rose nutrition may be dependant upon season in that a nitrogen-potassium ratio of 1:1 is recommended in summer and one of 1:2 in winter. However, we have yet to establish a scientific basis for this practice.