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PRACTICAL SECTION FOR GROWERS

Background and objectives

There are several reasons for wishing to accelerate the development of new roots in containerised roses. Plants are now being lifted and containerised as early as September in order to meet market requirements for sales of dormant plants. Visible evidence of fresh root when the rose is turned out of the pot at planting, and a stable pot-ball can be an important sign of quality in the eyes of the customer. Encouragement of root development following potting during cold conditions in the dormant season from mid November may improve establishment and help reduce over-wintering losses. And rapid root development is important when containerising plants from cold store in late spring and summer for extended season sales. Temperatures are higher and plant development is rapid at this time, so it is important that roots develop quickly and plant stress is minimised.

Enhanced new root development has been achieved with other woody nursery stock and tree species from the use of the synthetic auxins compounds IAA (indol-3-yl-acetic acid), NAA (2-[1-napthyl]acetic acid) and IBA (4-indol-3-yl-butyric acid), by dipping bare root transplants into solutions of these compounds. These are the same active ingredients as in commercially available formulations used to encourage the rooting of cuttings in horticulture. Responses with transplants have been variable according to the compound or mixture of compounds used, their concentration, temperatures and other factors. However, results appeared sufficiently promising to see whether a useful rooting enhancement could be achieved with containerised roses using a commercially available formulation of rooting hormone, Synergol (50:50 NAA+IBA).

Summary of results

Concentrations and two formulations were compared. As a liquid, Synergol at 500 mg/l ai and 1000 mg/l ai was applied to roots and shoots as a spray, and cut ends of roots were dipped into an experimental gel formulation of Synergol at 250 mg/l and 500 mg/l. The objective of the gel formulation was to see whether exposure of the roots to lower concentrations of hormone over a longer time would be effective. Pottings of Pretty Polly (patio), Freedom (HT) and Dearest (floribunda) were carried out in late September, mid December and from cold storage in late May.

Although some new roots were produced three to six weeks after potting from the autumn and winter potted batches, significant root development throughout the pot-ball did not occur until temperatures increased and shoot growth developed strongly in the spring and early summer. Plants potted into warmer conditions in May developed both roots and shoots very rapidly. None of the auxin treatments enhanced early root production.

Action points for growers

- The use of Synergol (50:50 IBA:NAA) as a root application (whether as liquid applied as a spray at 500 – 1000 mg/l, or in a gel formulation at 250 – 500 mg/l) on roses prior to containerisation, did not enhance root production and cannot be recommended.

- Because lower temperatures and minimal top growth in autumn and winter appear to be the main factors limiting new root development, it is probably unrealistic to expect a stable pot-ball to be achieved in time for sales of dormant containerised plants. Therefore consider labelling these as 'freshly potted' in line with European Nursery Stock Association Technical and Quality Standards for Roses.

SCIENCE SECTION

INTRODUCTION

Background

Field grown roses typically require severe root pruning before they can be containerised. Under good conditions, it has been shown that the roses budded on the most popular rootstock, *Rosa* 'Laxa', are capable of regenerating new roots relatively easily. Nevertheless, there are pressures now on nurserymen to lift and containerise as early as September to meet demands for autumn garden centre sales of dormant plants. There is, therefore, a danger that roses are planted out by the customer before sufficient new root has been established in the container to prevent the pot-ball from falling apart. Any enhancement of speed and quantity of rooting at this stage could be very beneficial.

Recent HDC (HNS 65) and MAFF (HH1513THN) funded projects have demonstrated the potential for potting from cold storage to extend the marketing period for containerised roses during the summer. Potting into warm conditions of spring and early summer encourages rapid growth, but it is important that shoot to root ratios remain in balance to avoid stress on the plant, which may lead to subsequent establishment failure. Again, enhancement of root growth is likely to aid this process.

Finally, pottings from about mid November - end January, can sometimes result in poorer establishment. Plants are dormant at this time, and may deteriorate before sufficient new root has developed leading to winter or spring deaths. Low temperatures during this potting period will be the main factor slowing new root development, but auxin treatments may, nevertheless, stimulate more root development either at this time, or in spring, and lead to more reliable establishment.

In horticulture, the promotion of rooting in cuttings using auxins, particularly the compounds IAA (indol-3-yl-acetic acid), NAA (2-[1-napthyl]acetic acid) and IBA (4-indol-3-yl-butyric acid), is well established. There are several commercial liquid and powder formulations, which have been available for many years. There is a small amount of published information in the scientific literature on enhanced new root formation that can occur when auxin applications are made to existing root systems to aid establishment. Struve and Moser (1984) found dipping root systems of scarlet oak (*Quercus coccinea*) seedlings into auxins including NAA could induce a 6-fold increase in root regeneration compared to control seedlings. Kelly and Moser (1983a, & 1993b) showed good responses in tulip tree (*Liriodendron tulipifera*) from root dipped seedlings prior to transplanting, using IBA at 1000 to 3000 mg/l. More recently, Percival (1998), working with *Betula pendula*, found dips containing IAA or IBA, or in combination, at 1000 mg/l promoted rooting vigour three or four times greater than controls. However, the use of NAA, alone or in mixtures with IAA or IBA, was not beneficial. Responses to different auxin compounds varied with species. Percival and Gerritsen (1998) drenched containerised plants with auxins and showed that NAA alone, or in combination with IAA and IBA, either had no effect or reduced root regeneration after

25 weeks with *Sorbus aucuparia* and *Alnus rubra*, but increased root regeneration with *Quercus robur* and *Tilia x europea*. IAA and IBA, both alone and in mixtures, were also effective with all these species. A total auxin concentration of 10,000 mg/l killed plants but 1000 mg/l did not. Hipps (1998), found that a root dip of IBA at 1000 mg/l gave significant increases in new root growth of beech (*Fagus sylvatica*) transplants some 50 days after planting, but there was some evidence that 2000 mg/l was less effective.

There is very little work of this nature on roses described in the literature. However, Fuchs (1986), working with cut rose cultivars on *R. canina* 'Inermis' rootstocks found IBA or NAA (50 and 500 mg/l) effective at promoting new root formation after treating dormant plants, whereas IAA showed no root promoting effect.

With this background of some promising research results, it was felt worthwhile undertaking a small scale investigation with higher value containerised roses, and a commercially available formulation of rooting hormone. It was important to see whether sufficiently useful results could be obtained for the technique to be quickly adopted for the industry.

Objectives

1 To observe the potential for improved root development and establishment of containerised rose crops potted early, mid-winter or late, by topical applications of a commercially available auxin formulation.

2 To obtain an indication of the effects of alternative concentrations and methods of application of the auxin.

MATERIALS AND METHODS

Treatments

Timing of treatment / crops

Three field grown rose crops were included:

i) September lifting and potting
ii) Dormant season (December) lifting and potting
iii) Late potting ex-cold store (May) but auxin treated before cold storage
iv) as iii) but auxin treated after cold storage just before potting

Cold storage was used to hold plants for treatments iii) and iv) dormant between the time they were lifted in December and potted in May. Treatment iii) was included to observe whether new root initiation could be stimulated in advance of potting during the period in cold store, particularly from the gel treatments.

Cultivars

Pretty Polly	Patio	Pink
Freedom	Large flowered (HT)	Yellow
Dearest	Cluster flowered (floribunda)	Rosy salmon

All plants were grown at HRI Efford from a crop of *Rosa* 'Laxa' rootstocks budded in summer 1996.

Auxin root treatments

Synergol, a commercially available product containing a mixture of the auxins NAA (0.5% w/w) + IBA (0.5% w/w) was used. In addition to using the normal liquid formulation on the roots, a gel formulation was also tried. The objective was to observe whether auxins would be more effective at similar or lower concentrations in a gel, which, in theory, would be available for absorption by the root over a longer period of time than from a liquid dip or spray.

1	Gel - Low	250 mg/l
2	Gel - High	500 mg/l
3	Liquid - Low	500 mg/l
4	Liquid - High	1000 mg/l
5	Untreated control	

Application of the gel was made to the roots after trimming them ready for potting. The end 1 - 2 cm of the roots was coated with gel by dipping them into a shallow tray containing the gel formulation.

The gel formulation for the September potting date was made up using a recipe based on sodium alginate as 'Protonal' (Pronova Biopolymer Ltd). This proved to be time consuming and difficult to prepare, and required a large quantity of alginate to obtain a thick enough consistency of gel.

For the December and two May potting treatments, a gel formulation using a hydroxypropyl methyl cellulose polymer was used more successfully. The particular polymer used, Courgel AG5000 (Courtaulds Chemicals Ltd), makes a reasonably thick gel at low concentrations, and is non-ionic in character and therefore compatible with a wide range of pesticides.

To make up the 500 ml of the 250 mg/l concentration of gel, for example, 12.5 ml of Synergol was added to 250 ml of water followed by 15 g of Courgel AG5000 powder while stirring. This was made up to 500 ml final volume with water to give a 3% w/v solution of Courgel and a 250 mg/l concentration of NAA + IBA auxins.

The rate of gel required for the root dip treatment averaged about 15 ml per plant.

The liquid spray treatment was applied to both the shoots and roots of the plant to runoff, and allowed to dry, before potting. This was to simulate the bulk dipping of crates of plants into a tank of solution, which might be the most commercially viable method of applying the auxin in a liquid formulation.

The rate of spray solution applied averaged about 25 ml per plant when applied to runoff.

Design

4 timings x 3 cultivars x 5 auxin treatments (4 auxin + control) = 60 treatments total.

6 plants potted per treatment. Total 360 plants.

The 6 plant treatment plots were not replicated further for this observation, as it was deemed that with the large number of treatments and plants being examined in total, any clear benefits or trends from the treatments would become evident.

Culture

Plants shoots were trimmed to about 130 mm long from the bud union, and roots to about 200 mm long after lifting from the field and prior to potting and, in the case of the May potted plants, before cold storage. Plants were potted into deep 4 litre pots in a standard potting mix of:

100%	Premium grade (medium / coarse) Shamrock Irish Moss peat
2.4 kg/m^3	Magnesian limestone
3.0 kg/m^3	Ficote 140 TE controlled release fertiliser (4.0 kg/m^3 used for May potting)

Three of the six plants per plot were potted with a polythene bag liner into which drainage holes matching those in the base of the pot were made (Plate 1, p. 21). This enabled plants to be examined for early root development without fear of the pot-ball collapsing.

Key dates

26/9/97	September batch auxin treated and potted. Held under glass with frost protection.
17/12/97	December batch auxin treated and potted. Both batches moved to an unheated polythene tunnel with netting sides and adjustable polythene skirts. Plants for the May potting were placed into cold store at 0 – 1°C and auxins for treatment iii applied before storage.
3/4/98	Plants moved to outside growing on beds.
21/5/98	May batches from cold store potted and auxins for treatment iv applied.

Plants were watered up well after potting and spaced pot thick while under glass or polythene. When moved to the outside growing beds, they were spaced in rows 270 mm apart by 300 mm in the row.

Plants were sprayed with fungicides against the major foliar diseases and insecticides for aphids, in a routine programme throughout the growing season. Some dieback of shoots of some plants after containerisation was observed during the trial (see Results section) and a high volume spray of dichlofluanid as Elvaron at 2.0 g/litre was applied to plants in mid February, while still under the polythene tunnel, after blackened ends of shoots were pruned back to healthy tissue. Other fungicides (HV to runoff) were used in rotation at approximately fortnightly intervals for protection against powdery mildew, black spot and rust, as follows:

bupirimate + triforine as Nimrod T at 3.2 mls/litre.
myclobutanil as Systhane 6W at 1.0 g/litre, or Systhane Flo at 1.0 ml/litre.
dodemorph as F238 at 1.25 mls/litre + carbendazim as Bavistin DF at 0.5 g/litre.

Fenpropimorph as Corbel at 0.7 mls/litre was used on one occasion in late June. However it caused some scorch to plant foliage. The product did not have label approval for use on roses, but following its recommendation for strawberry powdery mildew, had been tried on some field grown roses at Efford under the off-label arrangements for use at 'grower's own risk', with no apparent adverse effects. The aim was to broaden the range of fungicide groups included in the disease programme to minimise the development of fungicide resistance. However, risk of damage to containerised roses would limit its use.

One of the following insecticides (used in rotation) was included in a tank mix with the fungicides where necessary against aphids:

pirimicarb as Aphox at 0.5 g/litre.
deltamethrin as Decis at 0.7 mls/litre.
malathion as Malathion 60 at 1.9 mls/litre.
heptenophos as Hostaquick at 0.75 mls/litre.

Assessments

Root development

Three plants out of the six per plot, had been potted into a polythene liner within the container to allow early root development to be observed. Following each potting date, a sample of these containers was examined periodically to check for the first signs of new root growth. Once several containers showed new root activity, 'bagged' containers from each plot were inspected on a weekly basis and noted for the presence or absence of root. The quantity of root visible on the outside of the pot-ball was estimated either as the number of 'patches' of root visible or as a percentage of the area containing root patches. As a guide, once about half of the containers had at least 5% root cover, a more detailed rooting assessment was undertaken.

Pot-balls from each of the three bagged plants per plot were recorded for percentage root cover. The root systems were then washed out, and scored on a 1 (least) to 5 (most) scale for the amount of new root present. Photographs were also taken.

Shoot development and final quality at flowering

The stages of bud-burst and first expanded leaf were observed for each potting date. Following the sampling of the three bagged plants per plot for early root growth, the three remaining plants were grown on and recorded for final plant quality at the flowering stage. A score of 1 (poorest) to 5 (best) was given for each plant, and any dead plants noted.

Scores: 1 - Poor shape, shoot die-back present. Unmarketable.
3 - Up to 3 main branches, usually of varying vigour, affecting shape of plant. Minimum marketable quality.
5 - 4+ main branches of uniform vigour, good plant shape (even). First class quality.

Temperatures

Air temperatures were logged from mid October 1997, while the first batch of plants were under glass, through the December – early April period under the high tunnel, and finally while they were outside to when the final batch of plants had flowered and been assessed in early September.

RESULTS

General observations on survival and plant growth

Shoot die-back and plant losses

Plants did not remain dormant following the first potting on 26 September 1997, after plants had been placed under glass, with a flush of new leaves developing, but very little new shoot growth. Expanded leaf was present on Pretty Polly within a month of potting, followed by Freedom a week later, and Dearest a further two weeks later in mid November. However, by early February 1998, after the plants had been moved to the netting sided polythene tunnel, the leaves on Freedom, and to a lesser extent on Dearest, had developed Black Spot. A large number of purplish lesions were also present on stems of Freedom, together with shoot die-back. Dead shoot tissue was pruned back, and a spray of dichlofluanid as Elvaron at 2.0 g/litre applied. However many of the Freedom died or grew away again very poorly in the spring. Subsequent batches of plants (i.e. potted in December, or from cold store the following May) did not develop new leaves until early spring or summer, and Freedom from these batches remained healthy.

A few plants of Dearest developed some shoot die-back from the first two potting dates. However 'spring die-back' caused severe losses from the ex-cold stored plants potted in May, where about 70% of plants died and many of the remainder were of poor quality by the time they reached the flowering stage.

There was no pattern in the shoot die-back problems described above which appeared to be related to the applied auxin treatments.

Plants of Pretty Polly remained trouble free from all potting batches.

Delay in leafing out

An interesting treatment effect was noticed on the September potted plants relating to the rate of development of the October / November flush of leaves which occurred under glass. Both the low and high rates of auxin applied as a spray (to shoots as well as roots), delayed bud-burst and leaf expansion by one to two weeks in Freedom (Plate 2, p. 22), but there was no effect on the other cultivars. Neither was this phenomenon observed for any of the cultivars with the December or May potted batches.

Plants potted on 17 December started to burst bud under the ventilated polytunnel during February, with the earliest cultivar, Pretty Polly, reaching first expanded leaf by the end of the month, followed by Dearest and Freedom in early to mid March. Plants potted on 21 May developed leaves quickly, with the first expanded leaf stage reached within three to four weeks, except on plants of Dearest affected by spring die-back. Here, affected plants either developed leaves slowly and then died, or failed to leaf out at all.

Root development

Observations of first root development

Regular inspections were made to look for the first signs of new root growth visible on the outside of the pot-ball in the polythene bag lined containers. With both the 26 September and 17 December potted roses, some small patches of white root were first visible on Pretty Polly and Freedom after three to four weeks, while in Dearest it took about 6 weeks. However, the amount of root growth was still small, and somewhat variable between plants. Roots continued to develop slowly over the following few weeks, and the more detailed root assessment involving washing out of plant roots was carried out on 20 November and 11 March respectively for these two potting dates. No appreciable root growth sufficient to hold the pot-ball firmly together occurred in these two potting dates until vigorous vegetative growth started in the spring.

With the 21 May potting, which took place under warmer conditions, root development was much more rapid. Some roots were visible in one third of the plants just one week after potting, with three-quarters showing some roots after two weeks. Dearest was slower to develop roots, however, with a significant number of plants failing to produce any root at all. By a month after potting, most healthy plants had 10 – 30% root cover, and the detailed root assessment was carried out on 1 July at a more advanced stage of root growth than with the first two batches.

No treatment differences were obvious at this stage.

Detailed root assessments

Table 1, overleaf, shows the results for percentage root cover on the pot-ball and the rooting score after washing roots, as a mean per three plants plot assessed. Example illustrations of the rooting grades are shown in Plate 3, p. 23.

An important general finding was that the amount of new root growth at the time of assessment was quite small, and none of the auxin treatments gave any appreciable stimulation of early root growth. Data was not statistically analysed, but examination did not indicate any trends in the root cover percentages or scores that showed that the auxin treatments were having even a small effect on root development.

Root systems were examined, particularly for the gel treatment, to see whether the new roots arose from near the pruned ends of the old roots, which might have indicated some effect from this treatment, but again no clear evidence of this could be seen.

Although large numbers of Freedom died in early spring from the September potting, plants looked healthy at the time of the root assessment record in November, which was reflected by them having similar scores, overall, as the other cultivars. However, for Dearest in the two May potted treatments, which failed to establish well, poorer root development was clear at the root assessment stage. It is likely, therefore, that these plants were weakened or diseased prior to, or during, cold storage.

Table 1 **Root cover on pot-ball (%), and amount of new root score (1-5, 5 = greatest)**

Mean of 3 plants per plot

Treatment		Pretty Polly		Freedom		Dearest		Mean of cultivars	
		% root	root score	% root	root score	% root	root score	% root	root score
				25 September potting – recorded 20/11/97					
Gel	Low	8.0	5.0	3.0	3.0	1.7	1.7	4.2	3.2
	High	3.7	3.7	5.0	3.7	0.3	0.3	3.0	2.6
Spray	Low	4.3	3.7	2.3	3.0	5.0	2.7	3.9	3.1
	High	3.0	3.0	0.3	1.7	3.3	2.0	2.2	2.2
Untreated		6.7	5.0	3.0	3.7	1.7	1.0	3.8	3.2
				17 December potting – recorded 11/3/98					
Gel	Low	3.7	2.3	11.7	3.3	1.3	1.0	5.6	2.2
	High	10.0	3.7	10.0	5.0	2.0	0.7	7.3	3.1
Spray	Low	4.3	2.3	9.0	3.7	3.0	2.3	5.4	2.8
	High	4.0	1.7	13.3	5.0	5.7	3.0	7.7	3.2
Untreated		1.7	1.0	9.0	4.3	1.3	2.3	4.0	2.6
				21 May potting: treated pre-cold storage – recorded 1/7/98					
Gel	Low	20.0	3.7	16.7	3.0	3.3	0.7	13.3	2.4
	High	16.7	4.3	13.3	3.0	2.3	0.7	10.8	2.7
Spray	Low	10.0	3.0	23.3	4.3	6.3	1.7	13.2	3.0
	High	8.3	1.7	21.7	3.0	2.7	0.7	10.9	1.8
Untreated		18.3	3.0	18.3	3.0	1.4	0.7	12.7	2.2
				21 May potting: treated post-cold storage – recorded 1/7/98					
Gel	Low	16.7	3.7	20.0	3.7	5.7	3.0	14.1	3.4
	High	13.3	3.0	20.0	3.7	1.3	0.3	11.6	2.3
Spray	Low	13.3	3.0	18.3	5.0	1.3	0.7	11.0	2.9
	High	15.0	3.0	11.7	5.0	1.7	0.7	9.4	2.9
Untreated		13.3	3.0	14.0	5.0	2.0	0.7	9.8	2.9

Quality of plants at flowering

The September and December potted treatments were assessed on 27 May 1998, and the May potted treatments on 2 September 1998 (see Table 2 overleaf). Apart from the Freedom treatments potted in September and Dearest potted in May, where there were significant plant losses, in most cases final plant quality was good, and there was no evidence of any auxin treatment effect on final quality (Plate 4, p 24).

Temperatures

Temperature data for the containerised plants throughout the trial is summarised in Figure 1, p 15.

Table 2 **Quality at flowering. Mean score (1 – 5, 5 = best) of survivors from nominal 3 plants per plot.**

Treatment		Pretty Polly Score	Pretty Polly no. dead	Freedom Score	Freedom no. dead	Dearest Score	Dearest no. dead
		25 September potting – recorded 27/5/98					
Gel	Low	5.0	0	-	3	4.0	1
	High	5.0	0	-	3	4.3	0
Spray	Low	5.0	0	5.0	2	4.3	0
	High	5.0	0	3.0	2	5.0	0
Untreated		5.0	0	2.0	1	4.3	0
		17 December potting – recorded 27/5/98					
Gel	Low	5.0	0	5.0	0	5.0	0
	High	5.0	0	5.0	0	5.0	0
Spray	Low	5.0	0	5.0	0	5.0	0
	High	5.0	0	5.0	0	3.0	1
Untreated		5.0	0	5.0	0	3.7	0
		21 May potting: treated pre-cold storage – recorded 2/9/98					
Gel	Low	5.0	0	5.0	0	-	3
	High	5.0	0	5.0	0	-	3
Spray	Low	5.0	0	5.0	0	-	3
	High	5.0	0	5.0	0	2.0	1
Untreated		5.0	0	4.3	0	3.0	1
		21 May potting: treated post-cold storage – recorded 2/9/98					
Gel	Low	5.0	0	5.0	0	5.0	2
	High	5.0	0	5.0	0	5.0	2
Spray	Low	5.0	0	5.0	0	5.0	2
	High	5.0	0	5.0	0	-	3
Untreated		5.0	0	5.0	0	5.0	1

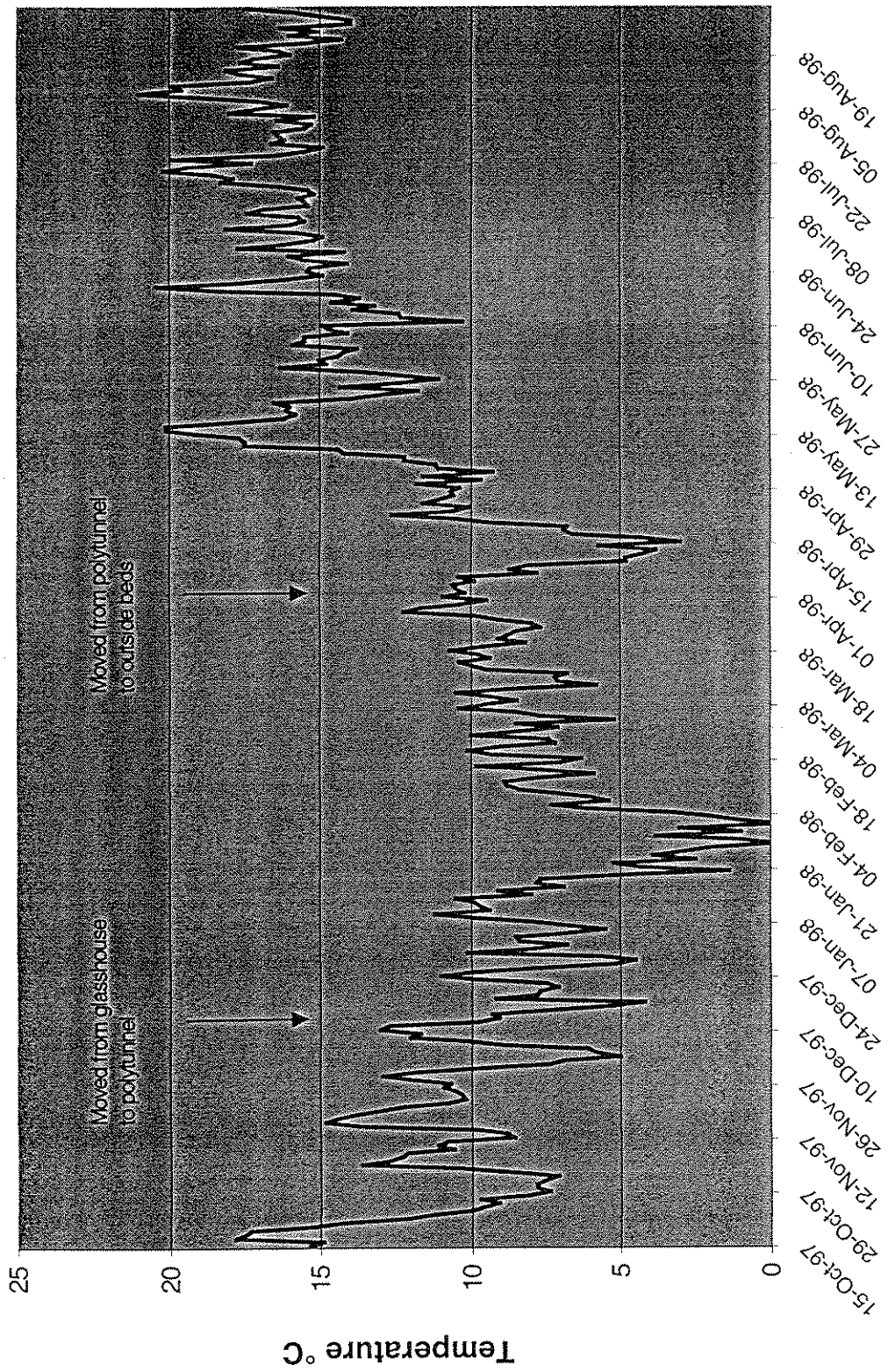

Figure 1 Mean daily air temperature of potted roses during trial

DISCUSSION

Clearly, none of the auxin application treatments used this study have shown any benefits in stimulating early root production with containerised roses, and therefore cannot be recommended at this stage. The literature references had indicated that a range of woody plants had shown positive responses to auxin root dips, and so it was disappointing that no apparent effect could be detected here. It is possible that the type of auxin used could be an important factor given the variable responses between auxins shown by other researchers. IBA alone at about 1000 mg/l would appear to be a promising candidate for further work. However it is interesting that in Fuch's experiment, IBA + NAA was effective, whereas IAA was not, and the Synergol product used here contained equal parts of IBA + NAA.

The mode of application could also be an important factor. It may have been that spraying the root (and shoot) system did not result in sufficient uptake into the roots, and immersion into a solution would have been better. In some of the literature, soaks of 30 seconds and 5 minutes are referred to, which is much longer than the '5 second quick-dip' typically used with liquid formulations when used for rooting cuttings. However, one might therefore have expected the Synergol in gel treatments (albeit with lower concentrations) to have shown some improved rooting responses due to the longer contact times.

The root systems of the roses were not excessively dirty when treated, but neither were they washed beforehand. A practical consideration for treating plants on a large commercial scale would be the quantity of soil that could be present on root systems after lifting from the field. It is very likely that an accumulation of this in any dipping solution used, or a significant amount on the roots at treatment, could affect the activity of the active ingredients.

While the gel formulation of Synergol was not effective in this particular instance, the use of Courgel 5000 as a non-ionic, and therefore relatively inert carrier for plant growth regulators or other pesticides, could be promising. Examples include the formulation of herbicide or fungicide gels for spot treatments.

Observations in this and earlier HDC projects with containerised roses have indicated that significant new root development tends to occur in parallel with new top growth. Apart from a small flush of new leaf growth following the September potting, new shoots mainly started growing from late February onwards in this project. Temperature is clearly a major factor affecting the rate of both root and shoot development. Figure 1, p. 15 shows a period when mean temperatures were generally > 10°C following the September potting when plants were under glass. This undoubtedly encouraged a little new root at this time, but plants were moving towards cooler temperatures and shorter days with a slow down in top growth as plants began to enter dormancy. In contrast, the final potting date of 21 May occurred when mean temperatures

were around 15°C, which encouraged very rapid development of both shoots and roots. Fuchs (1986) showed that optimum IBA concentration was lowest when plants were grown on at 25°C and *vice versa* for 5°C with cv. Sonia grafted onto *Rosa canina* rootstocks. Kelly and Moser (1983b) with *Liriodendron* seedlings showed that IBA gave relatively more root regeneration with higher soil temperatures over the 10 – 21°C range tested. Even though the May potting in this project did not demonstrate any benefits from auxin treatments, temperatures after treatment may be an important factor in the success of the technique. In any case, from the evidence shown here, the practice of early potting in September, with the main objective of obtaining significant root growth in advance of autumn sales, is questionable. It is understandable that early potting for autumn sales has increased to meet the demands for containerised roses at this time. However, the product is much more likely to have an unstable and crumbly pot-ball compared to the container rose sold in flower in early summer. The requirement for such roses to be labelled as "freshly potted" and not "container-grown", under the European Nursery Stock Association Technical and Quality Standards for Roses, recognises this fact.

This short project has shown that it was not possible to extrapolate some of the more promising results obtained with different subjects by other researchers to the containerised rose crop without further study. However, other possible treatments would need to make a dramatic improvement in rooting to achieve sufficient rooting from early autumn pottings to create a stable pot-ball. Given the relationship between temperatures and root growth discussed above, it is now uncertain that this is a feasible target. The cost of any promising treatments would also need consideration, since the current price of Synergol (concentrated product active ingredient at 10,000 mg/l) is around £50/litre.

CONCLUSIONS

- The use of Synergol (50:50 IBA:NAA) as a root application (whether as liquid applied as a spray at 500 – 1000 mg/l, or in a gel formulation at 250 – 500 mg/l) on roses prior to containerisation, did not enhance root production.

- Only a small amount of root growth occurred in the autumn from early lifting and potting in late September, despite holding plants under glass until mid December. Root development was generally slow from all potting dates until temperatures rose above 10 – 15°C in spring. Root and shoot growth tended to develop together in parallel.

- It is quite likely that further work with the synthetic auxins IBA, NAA and IAA, either alone or in mixtures, as well as application methods, would identify treatments that would give more positive rooting responses than found in this project. However, whether these would be of sufficient magnitude or cost effectiveness for adoption by rose growers is less certain.

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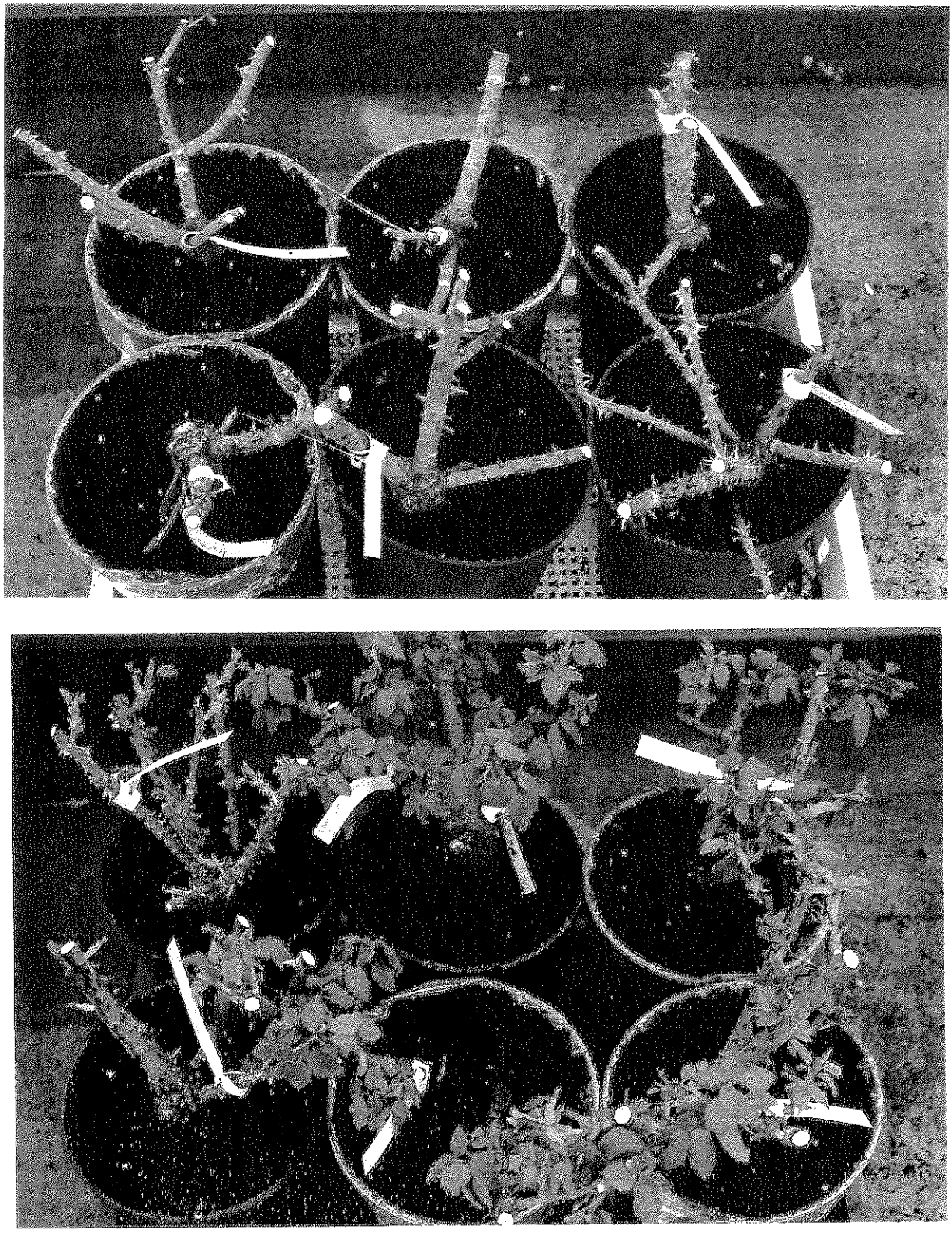
APPENDIX

Photographs

Plate 1

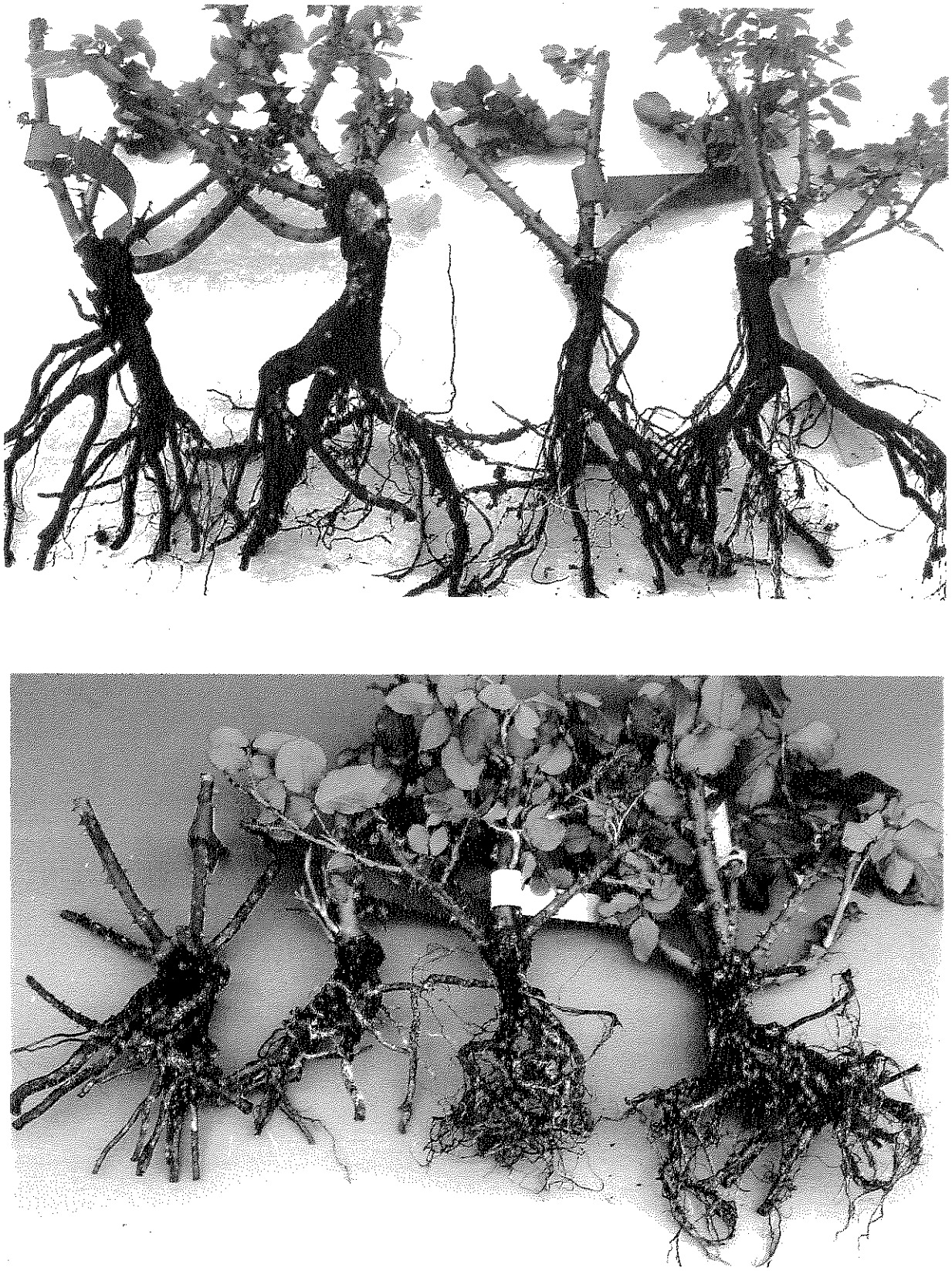
Dormant containerised roses including pots with a polythene bag liner to aid early inspection of root systems.

Plate 2



Freedom potted late September. Delay in breaking of buds four weeks after potting due to Synergol applied as an overall spray to plants (top) compared to a gel root dip formulation (bottom).

Plate 3



Early rooting assessment grades, left to right, 0, 1, 3 & 5. Assessment from September potting (top) 20/11/97, and from May potting (bottom) 1/7/98.

Plate 4

Plants on outside beds in late May. Pretty Polly (bottom).