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Production of container-grown nursery plants on capillary sand beds

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Abstract. This study investigated the effect of growth medium on the growth of nursery plants in a capillary irrigation system, the use and amount of slow-release fertilizer for the fertilization of container-grown nursery plants, and the need for a base dressing with a slow-release fertilizer. Also investigated were the effect of different concentrations of alkyl aryl trimethyl ammonium chloride solution (Gloquat C) in preventing rooting through, and the use of a watering control device based on measuring radiation energy in field conditions.

The experiments on growth medium revealed that all the growth media included in the experiment, i.e. sphagnum peat, peat/rock wool mixture (1 : 1), or peat/sand mixture (3 : 1), can be used for container-grown nursery plants if a base dressing is used with Nutricote(70), a slow-release fertilizer. The effect of slow-release fertilizer was better in peat mixtures, and this effect was especially clear when no base dressing was used. The use of slow-release fertilizer proved to be a good fertilization method in a capillary irrigation system. The fertilizing effect of Nutricote(70) given in the spring lasted until early June of the following year. Nutricote(70) was found to need a base fertilizer dressing. A base dressing of 1.2 kg/m^3 of a compound fertilizer (Turpeen Y-lannos; N 11 %, P 10.5 %, K 18.3 %) with 1.5 kg/m^3 of slow-release fertilizer proved to be a suitable fertilization method for ornamental woody nursery plants in a capillary irrigation system. The tallest plants were obtained with a base dressing that was mixed with 3 kg/m^3 of the slow-release fertilizer. Plants thus fertilized were, however, considered to be too large for transport and handling. The problem of a secondary root ball under the pot in sand beds was prevented by spreading 15 ml/m^2 of Gloquat C on the sand surface.

The capillary irrigation system and the automatic irrigation control worked well in experiments carried out under practical conditions. The potted nursery plants were kept evenly moist, and the plants grew to market size in one growing season.

Index words: Container-grown nursery plants, capillary irrigation, irrigation control device, slow-release fertilizer, Nutricote(70), growth media, prevention of rooting through, Gloquat C.

Introduction

The production of woody ornamental plants in the containers in which they will be sold is increasing. In particular, the spread of gardening centers has increased both the demand for and sales of potted nursery plants, because potted plants are more easily stored and handled than pre-packed and bare root plants. Container-grown nursery plants form a solid root ball, which ensures that they can be transplanted throughout the entire growing season.

In a nursery, the irrigation and fertilization of potted plants require care, because the water and nutrient reserves of the restricted growth medium are small in respect to plant needs. New and more efficient growing methods are being developed to reduce the labour costs of container-grown nursery plants. Capillary irrigation has proved to be an efficient irrigation method for container-grown nursery plants (PATEL and TINGA 1974, RICHARDS 1978, SCOTT 1979). Capillary irrigation is based on the capillary rise of water. The growth medium in the container absorbs water from moist sand or a capillary mat through holes in the bottom of the container (ANON. 1964, AUGER et al. 1977). Traditional fertilization methods cannot be used efficiently in a capillary irrigation system, because granular mixed fertilizers have no effect when applied to the surface of the growth medium. Further, if liquid fertilization is used, harmful amounts of nutrient salts may accumulate on the surface (HAVIS 1982). However, good results have been obtained using slow-release fertilizers (WARD and WHITCOMB 1979, HAVIS 1982, SWANSON et al. 1982). Slow-release fertilizers are more expensive than ordinary mixed or liquid fertilizers, but due to the long-term effect of the fertilizer, lasting e.g. two to three months, one application yields the same fertilization effect as do four to five separate applications of a compound fertilizer (RUDIN (1976). According to PENNINGSFELD (1975), the reduced labour need for fertilization and the better growth of plants compensate for the higher cost of fertilization.

A problem in capillary irrigation has been the growth of roots through the bottom holes of the container and into the capillary sand or mat (LOESER 1978, SCOTT 1978, SMITH 1982). Another annoying factor has been the growth of algae and weeds on the capillary bench (PIKE 1979). SMITH (1982) reported that several chemicals, such as cleaning agents, have been tested for prevention of secondary root balls under the pot. SCOTT (1978), SMITH (1982) and KNOBLAUCH (1985) have obtained good results using a quaternary ammonium compound (Gloquat C) for the prevention of rooting through.

The development of new growing techniques for container-grown nursery plants has combined capillary irrigation, the use of a slow-release fertilizer, and the prevention of rooting through with Gloquat C (SCOTT 1979). Capillary irrigation has been controlled with solenoid valves and timers (AUGER et al. 1977, SMITH and TREASTER 1980), and with an irrigation control device which measures the moistness of the capillary mat (ANON. 1976 a, FOX 1978).

Encouraged by British experiences, experiments were conducted, in 1984 and 1985 at a commercial nursery, to investigate the effect of growth media, slow-release fertilizers and Gloquat C on the growth of container-grown woody ornamental nursery plants in a capillary irrigation system. In the latter year, the capillary irrigation was automatized using a control device which measures radiation energy. The experiments were conducted by the Department of Horticulture of the University of Helsinki and Taimistoviljelijät ry, the Association of Nursery Growers.

Material and methods

Irrigation system and automatic irrigation control

The open-air capillary irrigation beds were 5×22 m in size. The beds were covered with 0.2 mm UV-protected plastic film. To remove excess irrigation water, plastic drainage pipes were placed on the plastic film and an overflow pipe was constructed to one end of the bed. The plastic and the drainage pipes were covered with a 10 cm layer of sand, of the following grain size:

>2 mm	25 %
0.6 —2 mm	29 %
0.2 —0.6 mm	30 %
0.06—0.2 mm	14 %
<0.06 mm	1 %

The capillary beds were watered with nozzles (R.I.S. Key Clip-nozzle) with a flow of 4 l/h at an operating pressure of 1 bar. One nozzle was used per square metre. An ITU-mikro KS 32 irrigation control device, which is based on measuring total radiation, was used in the experiment. The device had separate radiation integrators for the various irrigation modes; the integrators could be given a value for the sum of radiation energy (kWh/m^2) necessary at open the irrigation valves. The length of irrigation time and daily operating periods were also set and regulated by the device.

Fertilizer and growth medium experiments

The experiments investigated the effect of growth medium on the growth of nursery plants in a capillary irrigation bed, the need for a base fertilizer dressing when a slow-release fertilizer is used, as well as the use and quantity of slow-release fertilizer. The experimental plants were small plants of *Acer ginnala* Maxim., *Cotoneaster lucidus* Schlecht., and black currant (*Ribes nigrum* L. 'Öjebyn'). Three growth media were used: peat/sand, mixture 3 : 1; peat/rock wool, mixture 1 : 1; and pure peat. Limed peat (dolomitic limestone 10 kg/m^3) was mixed with 1.2 kg/m^3 of a compound fertilizer (Turpeen Y-lannos, N 11 %, P 10.5 %, K 18.3 %). The slow-release fertilizer, Nutricote (14-14-14, type 70), was applied with a measuring spoon to each bag during planting. The experimental plants were planted in 3-litre black plastic bags on May 14, 1984, and immediately moved to the capillary irrigation beds, 16 bags/m^2. Ten holes, with a diameter of 1.5 cm, had been made in the bottoms of the bags. The plants were first watered thoroughly by overhead irrigation; thereafter they were irrigated only from underneath. The fertilizer and growth medium experiments were factorial experiments with the following treatments:

Growth media: a_1 = peat/sand 3 : 1
a_2 = peat/rock wool 1 : 1
a_3 = pure peat

Base dressing: b_1 = no base dressing
b_2 = Turpeen Y-lannos 1.2 kg/m^3

Amounts of Nutricote(70) fertilizer:
c_1 = no Nutricote(70)
c_2 = Nutricote(70) 1.5 g/l
c_3 = Nutricote(70) 3 g/l

There were 18 different treatment combinations, with four replications. A total of 288 plants were included in one experiment. The same experiment design was used for nursery plants of black currant, *Cotoneaster lucidus* and *Acer ginnala,* which totalled 864 plants in all.

Prevention of rooting through

The aim of the exeriment was to determine whether alkyl aryl trimethyl ammonium chloride solution (Gloquat C) in capillary irriga-

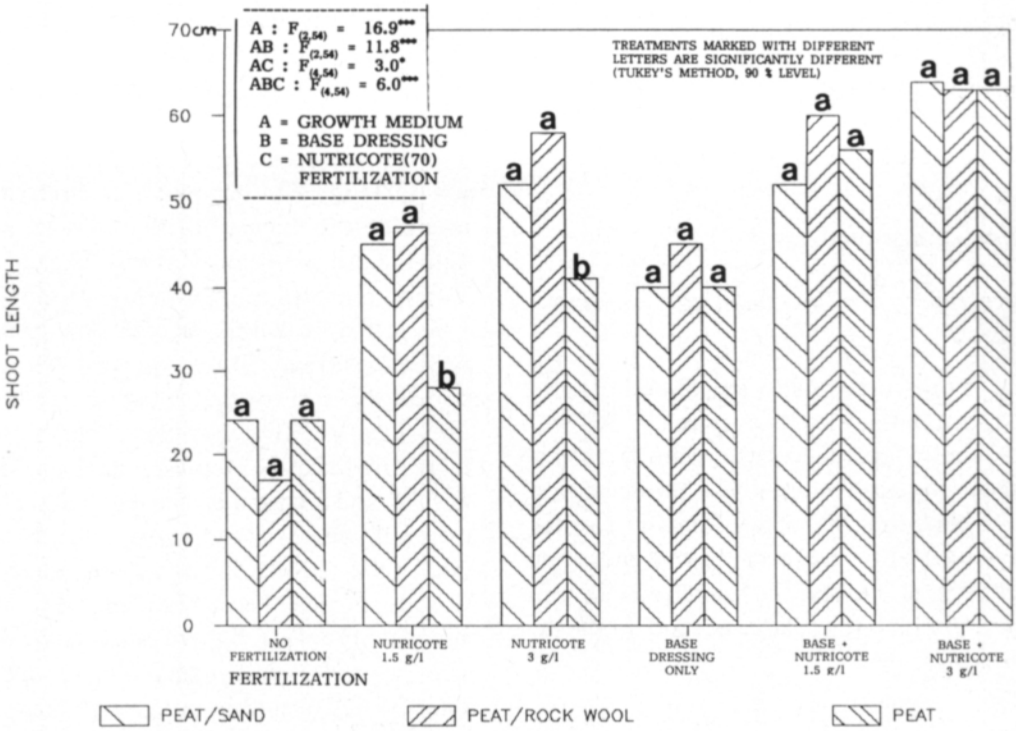

Fig. 1. Effect of growth medium on the shoot growth of *Cotoneaster lucidus* with different fertilization methods.

tion beds prevents rooting through. For the two treatments, 15 ml/4.5 dl/m² or 30 ml/4.5 dl/m² of Gloquat C was mixed with water. The foaming solution was spread on the experimental plots with a watering can. The experimental plant was common lilac (*Syringa vulgaris* L.). The plants were bare-root small plants which had been planted, in March, in three-litre plastic bags which had 10 holes, with a diameter of 1.5 cm, in the bottom. The growth medium was a mixture of peat and sand (5 : 1). The peat was limed with dolomitic limestone 10 kg/m³ and fertilized with a base dressing of 1.2 kg/m³ of 'Turpeen Y-lannos' (N 11 %, P 10.5 %, K 18.3 %). When planting, 6 g of Nutricote fertilizer (14-14-14, type 70) was added to each bag. There were three treatments:

a_1 = untreated
a_2 = Gloquat C 15 ml/m²
a_3 = Gloquat C 30 ml/m².

The experiment began on May 16, 1984. The experimental design was randomized blocks with five replications. Each experimental unit included 20 plants. The plants were brought to the plots promptly after the spreading of Gloquat C. The plants were first watered by overhead irrigation, but from two weeks after the experiment began, the only irrigation was from underneath. The observations were recorded at the end of August.

Results and discussion

Fertilizer and growth medium trial

Effect of growth medium on growth

The differences between the growth media depended on fertilization. When slow-release fertilizer with no base dressing was used, all shoots grew taller in peat mixtures than in peat. However, when a base dressing was applied together with the administration of slow-release fertilizer, the plants grew equally well in every growth medium (Fig. 1). One reason

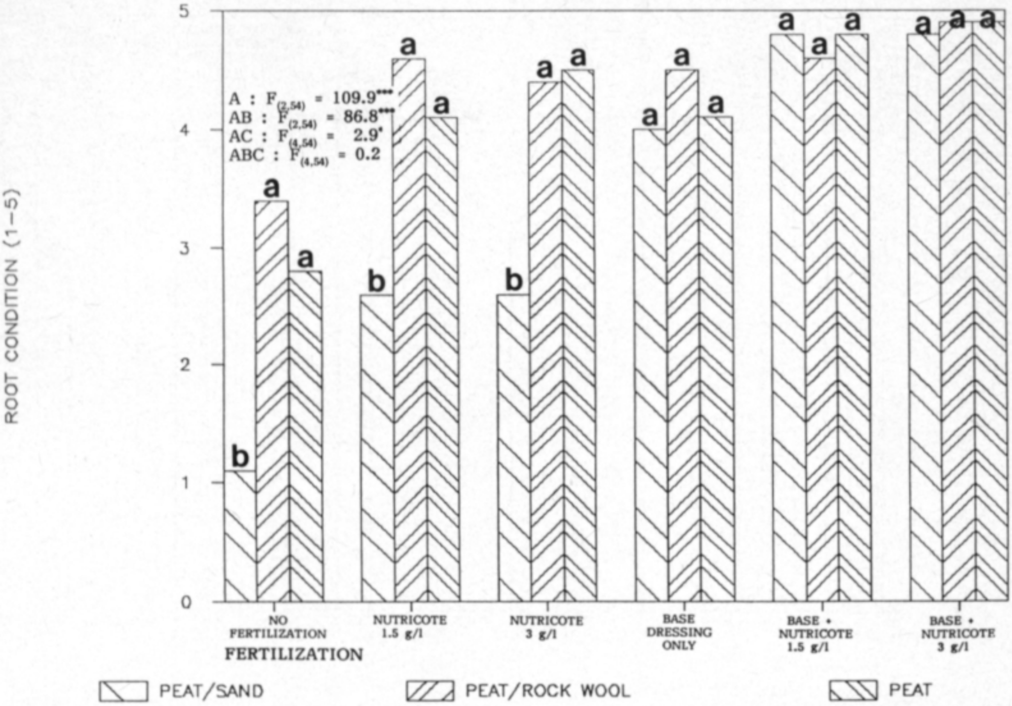

Fig. 2. Effect of the growth medium on root development of black currant *(Ribes nigrum)* with different fertilization methods. Grading scale 1—5: 1 = no root ball, no development of roots; 2 = no root ball, healthy root hairs; 3 = root ball breaks but stays together; 4 = solid root ball; 5 = perfect root ball.

why the nursery plants that received only slow-release fertilizer grew better in peat mixtures may be the better heat conductivity of the peat mixtures compared to pure peat (Larsson 1984); another possible reason is the faster release, with rising temperature, of the nutrients in Nutricote fertilizer (Shibata et al. 1980). Thus it is probable that the nutrients in Nutricote(70) were released more slowly in peat than in peat mixtures.

Black currant plants developed a thick root system in every growth medium, and the root ball was solid when a base dressing was combined with the administration of a slow-release fertilizer. In the peat/sand mixture (3 : 1) with no fertilizer and with Nutricote(70) without base dressing, the black currants did not develop a root ball at all (Fig. 2). *Acer ginnala* did not develop a marketable a root ball in peat with no base dressing or in the peat-sand mixture. *Cotoneaster lucidus* developed a thick root system in all growth media. Good growth was obtained in the peat/rock wool mixture (1 : 1). However, Bøvre (1984) and Larsson (1984) recommend a peat to rock wool ratio of 3 : 1. Rock wool is expensive, and its use is not economical. In addition, peat/rock wool bags are light in weight, and they may be blown over by the wind more easily than, e.g. peat/sand bags.

Effect of base dressing

The plants grew longer shoots when a base dressing was used than plants in the growth-media without base dressing (Fig. 3). The base dressing also affected leaf diameter. The leaves were larger when a base dressing was used. Black currant and *Acer ginnala* developed better root systems when a base dressing was used. *Cotoneaster lucidus* developed a dense root system regardless of the means of fertilization. This experiment justifies the conclusion that a base dressing should be used with Nutricote(70) fertilizer. Scott (1982)

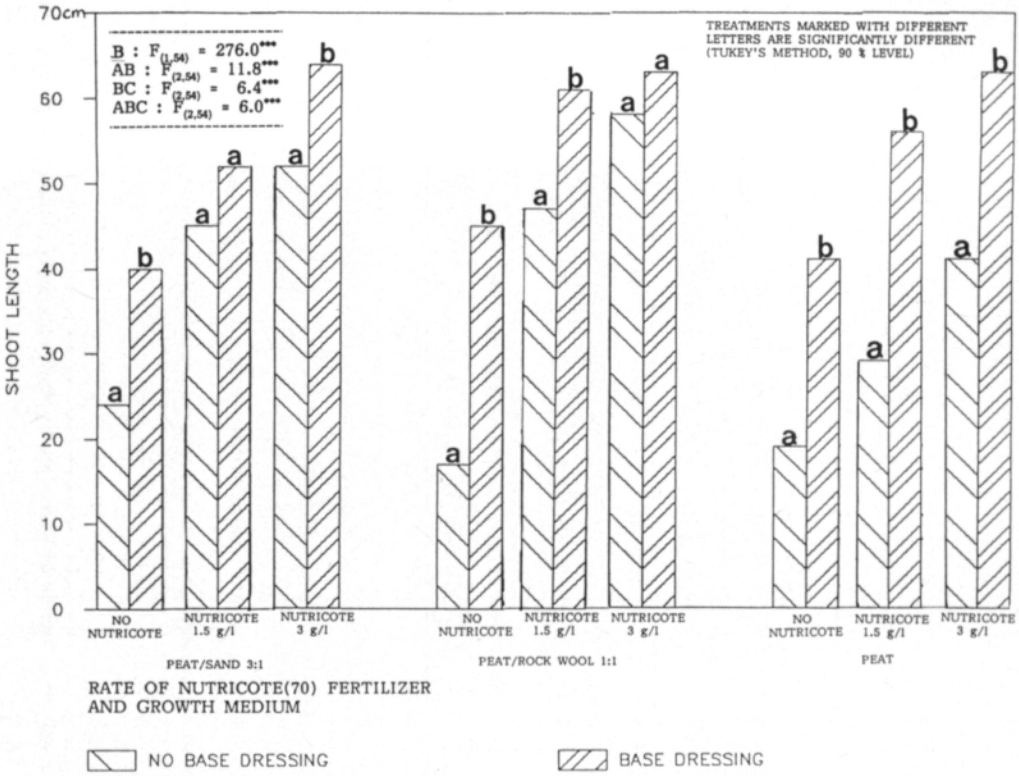

Fig. 2. Effect of a base dressing of fertilizer on the shoot growth of *Cotoneaster lucidus* in different growth media and given different amounts of Nutricote(70) fertilizer.

also found that a base dressing is required with the use of slow-release fertilizers.

Effect of Nutricote(70)

Those nursery plants fertilized with Nutricote(70) grew stronger than the others. The tallest shoots were obtained with the use of base dressing together with 3 g/l of the slow-release fertilizer. Plants thus fertilized were, however, considered to be too large for transport and handling. The difference between the two fertilizer quantities was not always clear (Figs 4 and 5), e.g. *Acer ginnala* plants grew as tall with 1.5 g/l of Nutricote(70) as they did when given 3 g/l of the same fertilizer. Plants fertilized with a base dressing and 1.5 g/l of Nutricote(70) were of market quality and had well-proportioned shoots. According to Scott (1979), fertilizer rates can be halved when capillary irrigation is used as compared with overhead irrigation, because the loss of nutrients due to leaching is smaller with capillary irrigation. Havis (1982), too, reported that 1.5 g/l of a slow-release fertilizer (Osmocote 18-6-12) is a suitable amount for sensitive-rooted ornamental bushes when capillary irrigation is used.

The leaves of the plants fertilized with the slow-release fertilizer were green or dark green, and their diameter was larger than leaves of the unfertilized plants or those grown only with a base dressing. The slow-release fertilized plants had a dense root system, and the root ball was solid. The roots gathered in the vicinity of the fertilizer grains, forming a dense net around the grain.

Foliar analysis in July showed that nutrient concentrations in the dry matter of the leaves of the plants fertilized with a base dress-

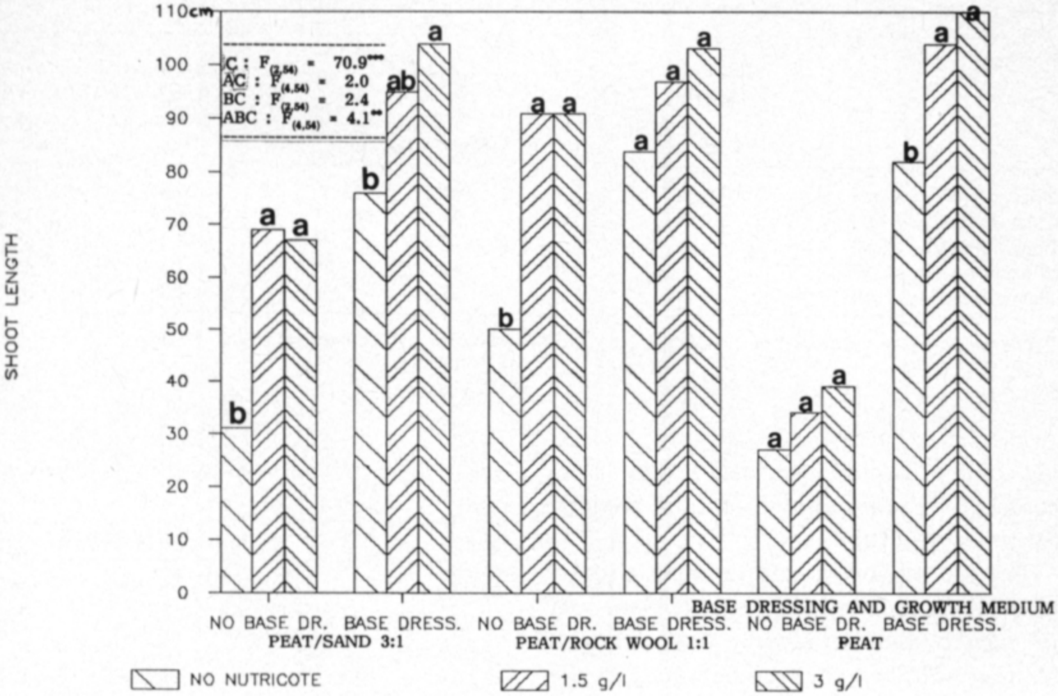

Fig. 4. Effect of Nutricote(70) fertilizer on the shoot growth of *Acer ginnala*.

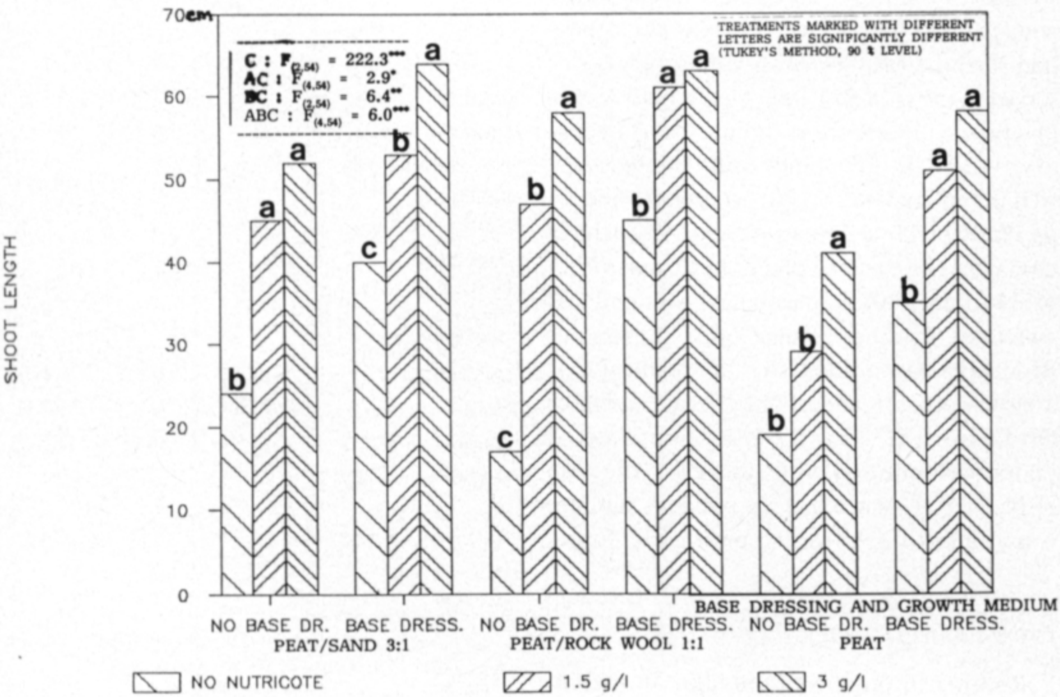

Fig. 5. Effect of Nutricote(70) fertilizer on the shoot growth of *Cotoneaster lucidus*.

Table 1. Nutrient concentrations in dry matter of black currant *(Ribes nigrum)* foliage samples.

Nutrient		Sample					
		Unfertil.	Nutric. 1.5 g/l	Nutric. 3 g/l	Base dress.	Base + Nutric. 1.5 g/l	Base + Nutric. 3 g/l
Nitrogen (N)	g/l	13.0	18.4	25.5*	15.4*	26.3*	32.6*
Calcium (Ca)	g/l	23.8*	25.4*	23.3*	25.4*	21.7*	22.7*
Potassium (K)	g/l	5.4	7.1	8.4	12.7	16.9*	18.0*
Phosphorus (P)	g/l	1.5	3.0*	2.9*	7.0*	7.8*	9.3*
Magnesium (Mg)	g/l	5.6*	5.8*	5.7*	5.0*	4.3*	4.6*

* The nutrient concentrations in dry matter are in accordance with the recommendations of SMITH (1976).

ing combined with Nutricote(70) were in accordance with the recommendations given by SMITH (1976) (Table 1).

The use of slow-release fer:ilizer also affected the woodiness of the shoots. Shoots of *C. lucidus* and *A. ginnala* fertilized with Nutricote(70) had not become woody by the end of August. The shoots of black currants became woody except for those treated with the highest fertilization amount, i.e. a base dressing and 3 g/l of the slow-release fertilizer.

By the end of October, the plants which were fertilized with a base dressing and Nutricote(70) still had leaves, whereas the others had shed their leaves. Overwintering was observed in the spring of 1985 after a hard winter (average temperature in January and February, —14°C). All plants overwintered very well in indoor storage, but *A. ginnala* and *C. lucidus* stored outdoors suffered some winter damage. The nursery plants fertilized with 3 g/l Nutricote(70), in particular, wintered less well than the other plants (Table 2). Van der BOON (1982) also noted that abundant use of a slow-release fertilizer may weaken winter hardiness. The growth of the overwintered plants was followed until June 1985; the dose of Nutricote(70) given in the previous summer was found to be effective until early June.

Prevention of rooting through

Rooting through was abundant in the untreated plots, but when Gloquat C treatment

Table 2. Effect of fertilizing method on winter hardiness.

Plant species and fertilizer	Overwintering method		
	Transplanted outdoors Oct 20, 1984	In sand beds without cover	Storage +0°C
Ribes nigrum			
Nutricote 3 g/l	4	4	4
Base dressing + Nutricote 1.5 g/l	4	4	4
Base dressing + Nutricote 3 g/l	4	4	4
Cotoneaster lucidus			
Unfertilized	3.3	4	4
Nutricote 1.5 g/l	2.8	3.8	4
Nutricote 3 g/l	2	2.5	4
Base dressing only	3.8	4	4
Base dressing + Nutricote 1.5 g/l	2.5	2.5	4
Base dressing + Nutricote 3 g/l	2.3	2	3.3
Acer ginnala			
Unfertilized	(2.3)[1]	(3)	(2.3)
Nutricote 1.5 g/l	(2.0)	(2)	(2.8)
Nutricote 3 g/l	(2.5)	(2.5)	(3)
Base dressing only	3.5	2.5	4
Base dressing + Nutricote 1.5 g/l	3.7	2.3	4
Base dressing + Nutricote 3 g/l	3	2.5	4

Grading scale 1—4: 1 = dead, 2 = more than half of shoots dead, 3 = ¼ of shoots dead, 4 = no damage.
[1] The parentheses indicate that these plants were originally weak.

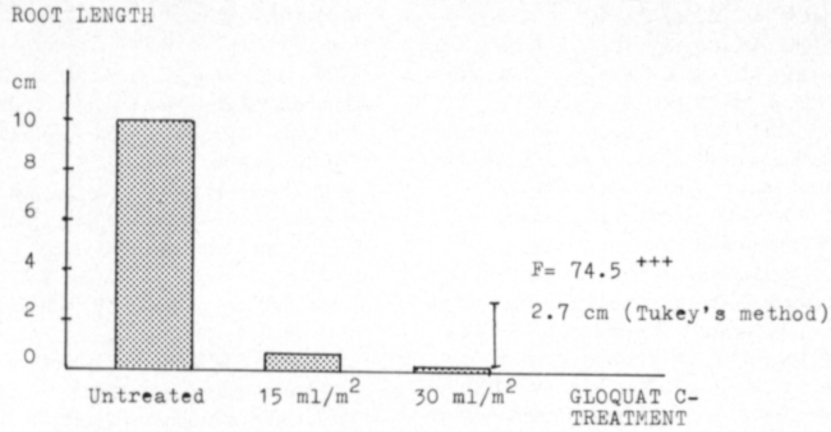

Fig. 6. Effect of Gloquat C on the growth of *Syringa vulgaris* roots outside the container.

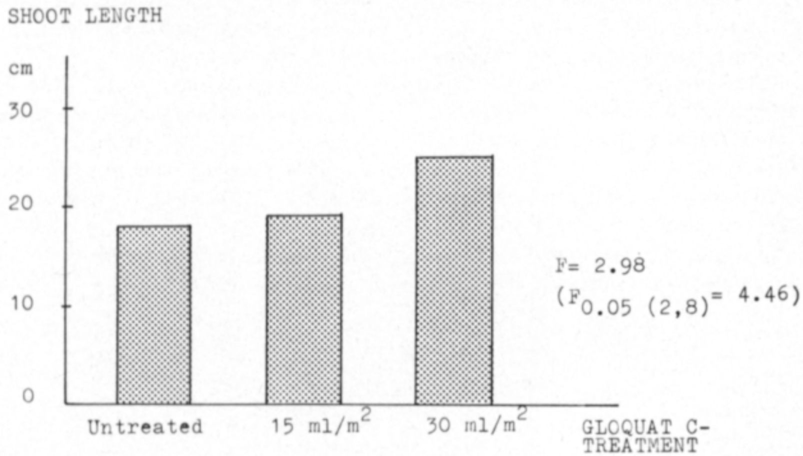

Fig. 7. Effect of Gloquat C on the shoot growth of *Syringa vulgaris.*

was used, rooting through was scarce or there were no roots in the capillary sand. Common lilacs in untreated plots had 10 cm long roots outside the container in August.

Both Gloquat C treatments were equally efficient in preventing the penetration of roots into the capillary sand (Fig. 6). The growth of shoots was equally good in untreated and treated plots, which shows that Gloquat C does not retard shoot growth (Fig. 7). It was noted that the effect of Gloquat C lasts the whole growing season. Scott (1978), Smith (1982) and Knoblauch (1985) have reported similar results.

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SELOSTUS

Astiataimien altakastelu taimistossa

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Helsingin yliopiston puutarhatieteen laitos

Astiataimina myytävien koristekasvien kysyntä ja tuotanto ovat lisääntymässä. Astiataimien kastelu ja lannoitus vaativat rajoitetun kasvualustan takia tarkkuutta ja runsasta työmäärää käytettäessä perinteisiä lannoitus- ja kastelumenetelmiä. Englantilaisten kokemusten rohkaisemana on Suomessa kokeiltu uutta astiataimien viljelytekniikkaa, jossa on yhdistetty veden kapillaariseen nousuun perustuva altakastelu, hidasvaikutteisten lannoitteiden käyttö ja taimien läpijuurtumisen estäminen Gloquat C-valmisteella. Tutkimuksen yhteydessä kastelujärjestelmä automatisoitiin auringon kokonaissäteilyn mittaukseen perustuvan kastelunsäätölaitteen avulla.

Tutkimuksessa selvitettiin kasvualustan vaikutusta taimien kasvuun altakastelujärjestelmässä, hidasvaikutteisen lannoitteen käyttöä ja käyttömäärää sekä sitä, tarvitaanko hidasvaikutteisen lannoitteen käytön yhteydessä peruslannoitusta. Samalla tutkittiin Gloquat C-valmisteen käyttövahvuuksia läpijuurtumisen estämisessä ja säteilyenergian mittaukseen perustuvan kastelunsäätölaitteen käyttöä altakastelun ohjaamiseen avomaan olosuhteissa.

Kasvualustakokeissa todettiin, että altakastelupedeissä voidaan astiataimien kasvualustana käyttää kaikkia kokeessa mukana olleita kasvualustoja, eli turvetta, turvekivivillaseosta (1 : 1) tai turvehiekkaseosta (3 : 1), jos hidasvaikutteisen Nutricote(70)-lannoitteen kanssa käytetään peruslannoitusta. Ilman peruslannoitusta taimet kasvoivat pisimmiksi seoskasvualustoissa.

Hidasvaikutteisen lannoitteen käyttö osoittautui hyväksi lannoitusmenetelmäksi altakastelujärjestelmässä. Keväällä annostellun Nutricote(70)-lannoitteen lannoitusvaikutus kesti seuraavan vuoden kesäkuun alkupuolelle saakka. Kokeissa todettiin, että hidasvaikutteista Nutricote(70)-lannoitetta käytettäessä tarvitaan myös peruslannoitus. Peruslannoitus turpeen peruslannoitteella 1.2 kg/m^3 ja 1.5 kg/m^3 hidasvaikutteista lannoitetta on sopiva lannoitus koristepensaan taimille altakastelujärjestelmässä. Hiekkapedeissä esiintyvä ongelmallinen juurten kasvu astian pohjareikien läpi hiekkaan ja rikkaruohojen ja levän kasvu altakasteluhiekan päällä saatiin estettyä levittämällä hiekan pinnalle Gloquat C-valmistetta 15 ml/m^2.

Altakastelujärjestelmä ja kastelunsäätöautomatiikka toimivat hyvin käytännön olosuhteissa tehdyissä kenttäkokeissa. Astiataimien kasvualustat pysyivät tasaisen kosteina ja taimet kasvoivat kauppakelpoisiksi yhden kasvukauden aikana. Kokeiden jälkeen havaittiin, että altakastelupedeissä kasvatetut taimet on kasteltava altapäin myös taimimyymälässä.