*Netherlands Journal of Agricultural Science 40 (1992) 269-275*

# Integrated nursery stock production

N.G.M. DOLMANS

Research Station for Nursery Stock, P.O. Box 118, NL 2770 AC Boskoop, Netherlands

Received 15 August 1991; accepted 6 December 1991

## Abstract

Nursery stock production in the Netherlands is a relatively small, though expanding industry. An immensely vast range of hardy plants is grown in containers or in the open soil with high inputs of fertilizers, soil sterilants and pesticides. Integrated production systems with low external inputs must be developed by adapting design and management of the nursery. Higher costs can be compensated by raising the efficiency of labour through expansion, specialisation, mechanisation, and automation. Three prototype integrated production systems are developed for: field-grown seedlings for forests, hedges and rose rootstocks; field-grown ornamental shrubs and conifers; and container-grown ornamental shrubs and conifers in a specially designed greenhouse. A nurseryman/researcher sets up and manages each experimental nursery. He is supported by a counselling group that defines the aims and judges the relevance of the results for research and practice. To support the prototypes additional research is carried out. Integrated nursery stock production is still at the beginning and its large-scale introduction will require several years, despite the great need to do so.

*Keywords:* nursery stock, trees, ornamentals, arboriculture, crop protection, integrated pest management, crop rotation, pesticides, mineral balance, fertilizers

## Introduction

Nursery stock production in the Netherlands includes an immensely vast range of hardy plants. More than 15 000 different species and cultivars are cultivated. These plants can be grown in containers or in the open soil. The main plant groups are solitary trees, trees for forests and hedges, roses, shrubs, conifers and perennial herbacious plants. On most tree nurseries a broad assortment of two or more plant groups is grown in different ways, so general statements about this sector are very difficult to give.

Nursery stock production is a relatively small though rapidly expanding and intensifying industry (Table 1), with an annual production value of 1.4% of the total national agricultural production. Up till now effects on the environment have hardly been considered so many cultures still depend greatly on high inputs of fertilizers and pesticides, especially soil sterilants (Tables 2 and 3).

The present use of fertilizers and pesticides still has a way to go to meet the long-term policy goals of the government. The use of pesticides has to be reduced by 25% by 1995, 39% by 2000 and 58% by 2010. Besides this reduction, further use of

Table 1. Characteristics of nursery stock production in the Netherlands.

| | 1975 | 1988 |
|---|---|---|
| number of nurseries | 3 600 | 4 450 |
| area open soil (ha) | 5 100 | 7 750 |
| area containers (ha) | 15 | 425 |
| total production value (NLG) | 198 106 | 613 106 |

Table 2. Estimated average annual use of pesticides (kg a.i.) in nursery stock production in the Netherlands.

| | Open soil | | Container | |
|---|---|---|---|---|
| | total ($\times 10^3$) | per ha | total ($\times 10^3$) | per ha |
| insecticides | 70 | 9 | 7 | 16 |
| fungicides | 93 | 12 | 4 | 10 |
| herbicides | 15 | 2 | 1 | 3 |
| sterilants | 395 | 51 | 0 | 0 |
| total | 573 | 74 | 12 | 29 |

Table 3. Estimated average annual use of fertilizers in nursery stock production (kg) in the Netherlands.

| | Open soil | | Container | |
|---|---|---|---|---|
| | total ($\times 10^3$) | per ha | total ($\times 10^3$) | per ha |
| N | 1340 | 173 | 230 | 532 |
| P | 190 | 25 | 30 | 73 |
| K | 550 | 71 | 200 | 465 |

about half of the registered pesticides is uncertain because of too high persistence, mobility in the soil or toxicity for water organisms. By 1995, emission of fertilizers has to be diminished by 50%, in 2000 the nitrate level in groundwater has to be less than 50 mg $l^{-1}$ and levels of total P and N in water emitted into surface water have to be less than 0.15 mg $l^{-1}$ and 2.2 mg $l^{-1}$, respectively. Because many plants are bought for their ornamental value and a high percentage of the production is exported, high quality standards must be met. A decline of quality can not be tolerated, so reduction of pesticides and fertilizers can only be achieved by developing efficient and reliable integrated production systems. It demands adaptation of nursery design and management, including crop assortment, cultural practice and technical equipment. Besides, the nurseryman has to invest more time in studying and monitoring his crops. In many cases integrated systems will require extra material and labour investments and could bring a certain reduction of yields. In nursery stock, production costs of fertilizers and pesticides are considered of minor importance, whereas labour costs are

40-50% of the total costs. This means that possible extra costs in an integrated system could be compensated by raising the efficiency of labor through, for example, expansion, specialization, mechanization, and automation. In this article integrated nursery stock production is defined, aims are described and a strategy for the development and introduction is set out.

## Materials and methods

### *Field-grown nursery stock*

A strategy for integrated nutrient management for field-grown nursery stock must be developed, inspired by the strategy for integrated arable farming (Vereijken, 1990). It implies the maintenance of soil fertility based on a nutrient balance to prevent leaching and overdosage as a cause of higher susceptibility for diseases. Since little is known about output and reserves of nutrients in nursery stock, chemical analysis of crops and soil should be intensified for better dosage of the input. Nutrient leaching into deeper soil layers can be restricted by using a model for nitrogen application (Neeteson et al., 1987) and the waterflow model for unsatured zones, SWATRE (Belmans et al., 1983).

To stimulate biological activity and maintain soil structure and fertility, organic manure must be used as much as possible. Additional mineral fertilizers have to be used because organic manure cannot cover the NPK needs of crops completely, and many soils have high P levels. Additional N and K fertilizers can be applied during the season, preferably in the rows. As the use of organic fertilizers is limited, special attention has to be given to the level of organic matter in the soil. This can be maintained by the use of compost and green manures.

The most common soil diseases and pests in open-soil nursery stock production are *Phytophthora cinnamoni, Verticillium dahliae, Meloidogyne hapla, Pratylenchus penetrans* and *P. vulnus*. Crop rotation, based on host ranges of these diseases and pests (Oostenbrink et al., 1957), should diminish or even replace soil sterilisation. Then nurserymen have to make a long-term plan, accepting certain limitations in the choice of their crops. Supporting investigations are needed on the effects of crop rotation on especially *Pratylenchus* spp. and the use of nematode-suppressing plants, such as *Tagetes*.

Better application techniques, as well as more knowledge of pests and diseases, good monitoring and decision support systems can lead to a reduction of the use of pesticides. In integrated systems, selective compounds are preferred. Integrated control programmes, e.g. for powdery mildew (*Sphaerotheca pannosa*) in *Rosa*, have to be developed. Mechanical weed control combined with row applications of herbicides are prefered. All these measures require better disease and weed management. This can only be achieved on a nursery if the number of crops is limited, making it worthwhile to pay more attention to them and to make specific investments.

*Container-grown nursery stock*

Container growing raises additional problems because it is very intensive. The main environmental problem is leaching and runoff of irrigation water containing fertilizers and pesticides into ground- and surface water. This can be solved by recirculation of the irrigation water. However, a separation between leachate and precipitation surplus has to be made. Various practical solutions for this problem are possible, depending on the size of the container and the irrigation method. A rather drastic way is to grow the plants indoors. In contrast to open soil production, soil sterilants are not needed (Table 2) in container production. In this sense container growing can be seen as an attractive alternative to field production. Besides, growing in a container indoors offers new opportunities for biological control in woody plants. Supportive investigations on climatic demands of the plants and on integrated pest management are needed. The use of plastic pots leads to undesirable waste, so they have to be recycled or biodegradable products have to be developed. Reduction of labour costs and better working conditions in container-growing can be achieved by mechanization, specialization and a better nursery layout. Although there are distinct differences, many technical solutions can be borrowed and adapted from floriculture (Welles, 1991)

*Development of prototype systems*

To gain more insight in the problems and perpectives of integrated production, three prototype nurseries were planned. Among the vast range of different crops and the diversity of nurseries, a choice had to be made for the development of the prototypes. Analysis of the size, urgency and complexity of the problems in relation to the significance of the plant groups led to the eventual choice of the prototypes. They will not be compared with other 'normal' nurseries, but will be judged on their own merits. At every prototype nursery one person will act as nursery manager, supported by a counsellinggroup includ the project leader, nurserymen and extension officers. The prototypes are:

1. nursery for field-grown seedlings for forests and hedges, and rose rootstocks on reclaimed peatland (Figure 1);
2. nursery for field-grown ornamental shrubs and conifers on sandy soil (Figure 2);
3. nursery for container-grown (1-3 l) ornamental shrubs and conifers in a 'convertible greenhouse'.

*Prototype 1.* For crop rotation on the nursery for field-grown seedlings, plant species are divided into four main groups; *Tagetes* is a fifth, additional group. Although still little is known about susceptibility to nematodes, this must be the base for this division, together with more general cultural practices. The nursery has an area of 1.5 ha and is divided in six equal main plots. Every main plot consists of four subplots, each of 0.06 ha, which is the smallest growing unit. On a main plot, one of the five plant groups is grown. On a subplot, one plant species within the group is chosen. In principle, a crop rotation system for the groups of 1:6 (or 2:6 for the binnial crops) is

Fig. 1. Crop rotation scheme for seedlings of forest and hedge plants, and rose rootstocks.

| Main plot | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | '91 | '92 | '93 | '94 | '95 | '96 | '97 | '98 | '99 | 2000 |
| I | D | C | E | E | B | A | D | C | E | E |
| II | A | D | C | E | E | B | A | D | C | E |
| III | B | A | D | C | E | E | B | A | D | C |
| IV | E* | B | A | D | C | E | E | B | A | D |
| V | E | E | B | A | D | C | E | E | B | A |
| VI | C | E | E | B | A | D | C | E | E | B |

A: rose rootstocks (one year); plant species: *Rosa canina* 'Inermis', *R. canina* 'Pfänder', *R. corymbifera* 'Laxa', *R. multiflora.*
B: *Tagetes* (one year).
C: other *Rosaceae* (one year); plant species: *Crataegus monogyna, Prunus avium, P.* 'St. Julien A', *Malus sylvestris.*
D: sown forest and hedge plants (one year); plant species: *Acer platanoides, Alnus glutinosa, Betula* spp., *Fagus sylvatica, Fraxinus excelsior, Quercus robur.*
E: transplanted forest and hedge plants (two years, except for E*); plant species: *Acer platanoides, Fagus sylvatica, Fraxinus excelsior, Pinus sylvestris, Quercus robur.*

planned. Changes can be made, depending on the nematode populations, the availability of seed and planting material and results of other crop rotation experiments. As the soil is phosphate saturated, animal manure cannot be used for fertilization in the first years. Composted waste materials and green manures will be used to compensate the loss of organic matter by mineralization. Weeds will be controled mechanically between the rows by hoeing, ridging and brushing. In the rows, frequent sprayings with low dosages of contact herbicides can be used or sometimes it will be still necessary to use soil herbicides. On seed beds, weeds are killed by infra-red burning. A list is made of pesticides that can be applied and that conform to future governmental standards on side-effects on the environment. These pesticides will be applied with technically advanced spraying equipment.

*Prototype 2.* Plants grown on the nursery for field-grown ornamentals are divided into six rotation groups. *Tagetes* is the seventh rotation crop. Susceptibility to nematodes and *Phytophthora cinnamomi* and general cultural practices are the base for this grouping. Plants are grown from planting stock to saleable plant in two years. After four years (two crops) *Tagetes* is grown for one year. The whole nursery is 0.8 ha, divided in eight main plots. Every main plot consists of three subplots of 0.033 ha; these are the smallest growing units. On a main plot, one of the seven plant groups is grown. On a subplot one plant species within the group is chosen. In principle, a crop rotation system for the groups of 2:15 is planned. Fertilization and plant protection are in general the same as described for prototype 1, except that more organic material has to be applied, because some plants are sold with a rootball.

*Prototype 3.* The container nursery consists of a greenhouse of 0.2 ha with a remov-

Fig. 2. Crop rotation scheme for ornamental shrubs and conifers.

| Main plot | Year | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | '91 | '92 | '93 | '94 | '95 | '96 | '97 | '98 | '99 | 2000 | '01 | '02 | '03 | '04 | '05 |
| I | A | G | C | C | F | F | G | A | A | D | D | G | B | B | E |
| II | D | D | G | B | B | E | E | G | A | A | D | D | G | C | C |
| III | C | C | F | F | G | A | A | D | D | G | B | B | E | E | G |
| IV | G | A | A | D | D | G | B | B | E | E | G | C | C | F | F |
| V | G | E | E | G | A | A | D | D | G | C | C | F | F | G | B |
| VI | F | F | G | A | A | D | D | G | B | B | E | E | G | A | A |
| VII | B | B | D | D | G | C | C | F | F | G | A | A | D | D | G |
| VIII | G | B | B | E | E | G | C | C | F | F | G | A | A | D | D |

A: *Rosaceae:* cultivars of *Rosa, Potentilla, Malus, Prunus, Amelancier.*
B: evergreen shrubs: cultivars of *Mahonia, Ilex, Viburnum.*
C: deciduous shrubs: cultivars of *Callicarpa, Magnolia, Cornus.*
D: conifers susceptible to *Phytophthora cinnamomi:* cultivars of *Chamaecyparis, Taxus.*
E: conifers (*Cupressaceae*): cultivars of *Juniperus, Thuja.*
F: conifers (*Pinaceae*): cultivars of *Abies, Picea, Pinus.*
G: *Tagetes.*

able plastic roof ('convertible greenhouse'), protecting the system from excess rain. The roof can be opened to obtain a mild climate for growing and hardening off. Mainly shrubs and conifers that can be sold as a visually attractive product are grown from rooted cutting to saleable plant (Table 4). Plants are grown in 1-3 l containers in lots of 0.01 ha or 0.02 ha on a concrete floor, to facilitate mechanisation. An automated system for potting, transporting, placing and spacing the containers avoids undesirable working conditions and reduces labour costs. Plants are fertilized with every irrigation, the leachate is collected and reused. Biological control of aphids (with *Aphidoletes aphidomyza* and *Aphidius matricariae*), spider mite (with *Phytoseiulus persimilis*) and black vine weevil (with *Heterorhabditis* sp.) is being devel-

Table 4. List of plants for the prototype container-grown ornamentals.

| |
|---|
| *Berberis thunbergii* 'Atropurpurea Nana' |
| *Calluna vulgaris* 'Ralph Purnell' |
| *Caryopteris clandolinensis* 'Kew Blue' |
| *Ceanothus* 'Gloire de Versailles' |
| *Daboecia cantabrica* 'Atropurpurea' and 'Cinderella' |
| *Euonymus fortunei* 'Sunshine' |
| *Genista lydia* |
| *Hederea helix* 'Goldheart' |
| *Ilex aquifolium* 'J.C. van Tol', 'Silver queen' and 'Golden King' |
| *Photinia fraseri* 'Red Robin' |
| *Skimmia japonica* 'Rubinetta' |
| *Chamaecyparis lawsoniana* 'Stardust' |
| *Juniperus communis* 'Hibernica' |
| *Juniperus media* 'Old Gold' |

oped. Pesticides used for correction or to control other diseases and pests have to fit this system.

At the three prototype nurseries, equipment and the way of growing can be quite different from a usual nursery, so unforeseen problems can be expected. An initial aim is to gain a good insight into the possibilities and practical value of integrated methods, combined with each other within a well-planned nursery. In due course, as new knowledge becomes available it can be introduced and tested in the prototype. Aims can be adjusted if more data on the economic and environmental results become available. In this process the counselling group is supposed to have an active role.

## Perspectives

Although the size of the prototype nurseries is too small to be economically viable, the scale of the different cultures is chosen representatively. Data obtained from the separate cultures and general nursery data will be a base for the evaluation of new plans for integrated nursery stock production. The prototypes are situated in important production centres for nursery stock in the Netherlands, easy accessible for the growers. Results will be published regularly in nursery magazines. Excursions can be made and open days will be held at least once a year, in cooperation with extension services. These services also play an important role in the introduction in practice.

Additional research to support the development of integrated systems has been started and current research projects on crop protection and fertilization have been adapted to the needs of integrated methods. Still, the limited research capacity and the lack of time is a matter of concern.

There are good chances for a successful large-scale introduction of integrated nursery stock production. However, in the short term, integrated production will certainly be not cheaper for the individual nurseryman, and nursery stock production is a rather conservative industry. For these reasons the introduction of integrated systems in practice should be accomodated by a balanced package of rewards for positive and penalties for negative practices for the environment.

## References


Belmans, C., W.G. Wesseling & R.A. Feddes, 1983. Simulation model of the water balance of a cropped soil: SWATRE. *Journal of Hydrology* 63: 271-286.

Neeteson, J.J., D.J. Greenwood & A. Draycott, 1987. A dynamic model to predict yield and optimum nitrogen fertiliser application rate for potatoes. Proceedings of the Fertiliser Society, No. 262, 31 pp.

Oostenbrink, M., J.J. s'Jacob & K. Kuiper, 1957. On the hosts of *Pratylenchus penetrans*. (In Dutch). *Tijdschrift voor Plantenziekten* 63: 345-360.

Vereijken, P., 1990. Integrated nutrient management for arable farming. *La Recherche Agronomique en Suisse* 29: 359-367.

Welles, G.W.H., 1991. Integrated production systems for glasshouse horticulture. *Netherlands Journal of Agricultural Science* 40: 277-284.