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AUGĻUKOKU UN OGULĀJU PAVAIROŠANA UN STĀDU AUDZĒŠANA – NO TEORIJAS LĪDZ PRAKSEI

PROPAGATION AND NURSERIES OF FRUIT TREES AND SOFT FRUITS – FROM THEORY TO PRACTICE

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Content

NURSERY VALUE OF SOME DWARFING CHERRY ROOTSTOCKS IN HUNGARY
ZEMA AUGUMA ĶIRŠU POTCELMU VĒRTĒJUMS KOKAUDZĒTAVĀ UNGĀRIJĀ

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Kopsavilkums

Izmēģinājumā tika salīdzināti potcelmi GiSelA 5 un GiSelA 6 ar Cerasus mahaleb formu ‘Cema’, kura tiek tradicionāli izmantota kā saldo ķiršu potcelms Ungārijā. Sešas jaunizveidotas saldo ķiršu šķirnes (‘Rita’, ‘Carmen’, ‘Péter’, ‘Vera’, ‘Aida’, ‘Alex’) tika acotas uz šiem potcelmiem un izvērtētas kokaudzētavā no 2001. līdz 2003. gadam. Būtiskas atšķirības acojumu pieaugumā starp variantiem netika konstatētas. GiSelA potcelmu ietekme uz koka augumu bija novērojama jau kokaudzētavā – augu augstums bija par 29-55% zemāks un stumbra diametrs par 4-45 % mazāks kā kontroles variantam. Sānu dzinumi neveidojās uz kokiem, kuri acoti uz GiSelA potcelmiem, bet uz ‘Cema’ - veidojās sasteigtie dzinumi.

Abstract

There is a keen interest in intensive sweet cherry (*Cerasus avium* L. Mönch.) growing in Hungary. Smaller tree size is essential for this technology; in an intensive orchard the pathogens and pests can be better controlled, thus more effective and environment safe plant protection can be done. It is very easy to prune the orchard, the trees begin yielding earlier, and the cost of picking is lower than in a traditional orchard. GiSelA 5 and GiSelA 6 rootstocks were chosen to compare their values to Cerasus mahaleb ‘Cema’ which is the standard cherry rootstock in Hungary. Six newly bred sweet cherry cultivars (‘Rita’, III-42/114 (‘Carmen’), IV-6/5 (‘Péter’), ‘Vera’, IV-13/20 (‘Aida’ and ‘Alex’) from the Research Institute’s breeding programme were budded on them. Observations were made in a nursery from 2001 till 2003. There were no significant differences in bud take compared to the ‘Cema’ rootstock. The dwarfing effect of GiSelA rootstocks occurred already in the nursery stage, since the height of the budded cultivars on GiSelA rootstocks was 29-55 % and trunk diameter 4-45% smaller than those by the control variant. No secondary branches were produced on the budded cultivars on GiSelA rootstocks while the trees on ‘Cema’ seedling produced feathers.

Key words: dwarfing cherry rootstocks, nursery value.

Introduction

In Hungary there is a keen interest, in planting intensive orchards of sweet cherry (*Cerasus avium* (L.) Mönch.) similarly to other fruit species. There are a lot of advantages of the intensive fruit growing due to smaller size of trees compared to „traditional” ones. In an intensive orchard the growers can exploit biological and ecological potential of the site to produce the highest possible yield and the best fruit quality (Papp, 1997). This technology can be realized by using dwarfing rootstocks.

The Research Institute for Fruitgrowing and Ornamentals of Budapest-Érd searches for perspective foreign-bred dwarfing rootstocks to its novel sweet cherry cultivars and hybrids. It is very important to test the new dwarfing rootstocks under Hungarian climate conditions as they differ from those in Western Europe. In Hungary soils are more calcareous and the climate is drier compared to Western Europe, therefore why it is important to know lime- and drought-tolerance of the roots.

Worldwide most planted dwarfing rootstock is of the GiSelA series (Franken-Bembenek 2004, Bujdosó and Kállay 2004). Compared to F 12/1 the dwarfing effect of GiSelA 5 on the growth of budded cultivars is 48-77 % higher and the budded cultivars’ yield is 2-3 times higher. The growth of cultivars grafted on GiSelA 6 is stronger than growth of cultivars grafted on GiSelA 5. The sweet cherry cultivars on GiSelA 6 have 10 % bigger trunk cross sectional area than that of cultivars on GiSelA 5. Both dwarfing rootstocks have very good compatibility (Franken-Bembenek, 1998, 2004).

Materials and Methods

A rootstock trial was set up at the experimental farm of the Research Institute for Fruitgrowing and Ornamentals of Budapest-Érd in 2001 and 2002 to evaluate the GiSelA 5 and GiSelA 6 dwarfing rootstocks. The control of the trial was *Cerasus mahaleb* L. 'Cema' (syn.: C 500) which is used in 70% of the Hungarian sweet cherry orchards.

After planting the rootstocks budded in August of 2001 and 2002 of 3 sweet cherry cultivars ('Rita', 'Vera', 'Axel' (syn.: 'Alex')) and 3 sweet cherry hybrids (III-42/114 ('Carmen'), IV-6/5 ('Petrus') (syn.: Péter), IV-13/20 ('Aida')), bred at the Research institute, were.

In the year after budding (2002 and 2003 resp.) bud take (Table 1), height of trees (20 trees/rootstock/scion combination), trunk diameter at 30 cm over the graft (Table 2), and number of lifted whips and feathered trees (Table 3) were assessed. Trees with at least 100 cm high trunk and at least 3 laterals. Statistical differences between the stock/scion combinations were calculated by Duncan's Multiple Range Test.

Results and Discussion

According to data assessed in 2002 and 2003 every scion variety took well on 'Cema' mahaleb seedling rootstock, on GiSelA 5, and on GiSela 6 (Table 1). The best bud take of 'Rita' and IV-13/20 ('Aida') was on 'Cema' mahaleb stock, that of 'Vera' 'Axel' and III-42/114 ('Carmen') - on GiSelA 6, while IV-6/5 ('Petrus') showed the best results on GiSelA 5. Calculating the average of the take of the 6 scion varieties the best take (79 %) was on GiSelA 6, then follow 'Cema' (77 %) and GiSelA 5 (71 %). These facts agree with the findings of Franken-Bembenek (1995).

The height of the trees on GiSelA 5 was by 29 to 53 % less, and on GiSelA 6 by 32 to 55 % less than on 'Cema' mahaleb stock (Table 2). Trunk diameter data gave very similar results: the measured data of the scion varieties were by 25 to 45 % and 4 to 35 % less than in the control (Table 3).

Table 1. Bud take of new cherry cultivars budded on 'Cema' mahaleb seedling and GiSelA 5 and GiSelA 6 dwarfing rootstocks, % (Érd-Elvira major, average of 2002-2003)

	Bud take					
Rootstocks	of 'Rita'	of III-42/114 'Carmen'	of IV-6/5 'Petrus'	of 'Vera', %	of IV-13/20 'Aida'	of 'Axel'
'Cema'	81[1]a	71[1] a	82[1] a	83[1] a	74[1] a	76[1] a
GiSelA 5	70 b	68 b	86 b	80 a	56 b	67 b
GiSelA 6	75 b	75 a	80 a	90 b	65 c	90 c

[1]: Multiple range test, α=0.05

Table 2. Height of one-year-old sweet cherry trees in the nursery, cm (Érd-Elvira major, average of 2002-2003)

	Height					
Rootstocks	'Rita'	III-42/114 'Carmen'	IV-6/5 'Petrus'	'Vera'	IV-13/20 'Aida'	'Axel'
'Cema'	191[1] a	212[1] a	227[1] a	240[1] a	200[1] a	218[1] a
GiSelA 5	136 b	104 b	133 b	149 b	114 b	103 b
GiSelA 6	129 b	103 b	123 b	138 b	109 b	122 b

[1]: Multiple range test, α=0.05

Statistical examination of trunk diameter data showed significant difference. Every combination on dwarfing rootstocks met the specifications of the Hungarian nursery standards (Anonym. 2004). These results also agree with those described by Franken-Bembenek (1995), who the found a dwarfing effect of 30 to 40 % compared to the control trees. Investigating the young trees on dwarfing stocks GiSelA 5 and GiSelA 6 as a group they showed statistical homogeneity, except IV-13/20 ('Aida') and 'Axel'.

Trunk diameter of these two season varieties differed significantly from that of the groups.

Table 3. Trunk diameter of one-year-old sweet cherry trees in the nursery, cm (Érd-Elvira major, average of 2002-2003)

	Trunk diameter					
Rootstocks	of 'Rita'	of III-42/114 'Carmen'	of IV-6/5 'Petrus'	of 'Vera', %	of IV-13/20 'Aida'	of 'Axel'
'Cema'	17[1] a	19,4[1] a	19,4[1] a	19,3[1] a	19,7[1] a	19,3[1] a
GiSelA 5	12,8 b	10,8 b	10,8 b	13,9 b	12 b	12,1 b
GiSelA 6	16,4 a	15,4 b	15,4 b	15,9 b	14,8 c	14,9 c

[1]: Multiple range test, α=0.05

As to feathering of young trees, research results were less favourable. Most trees on 'Cema' mahaleb rootstock were well feathered, while those on GiSelA stocks had no laterals (Table 4). These facts contrast with the experience of German researchers (Vogel, 2001). GiSelA dwarfing rootstocks proved rather profitable in the nursery: they can be easily propagated and show good compatibility with a wide range of scion varieties. However, in the (bearing) orchard most estimation is not as appreciative in Hungary. Under less favourable climate (less precipitation) than that of Western Europe, unfavourable traits and symptoms come to dominance: early ageing, getting barren early, fruit quality worsen year by year, weak regenerative capacity (Bujdosó *et al*., 2004). Thus planting nursery trees on GiSelA 5 or GiSelA 6 is useful only at the best growing sites or possibly in irrigated plantations.

Table 4. Ratio of the feathered trees in the nursery, % (Érd-Elvira major, average of 2002-2003)

	Ratio of feathered trees					
Rootstocks	of 'Rita'	of III-42/114 'Carmen'	of IV-6/5 'Petrus'	of 'Vera', %	of IV-13/20 'Aida'	of 'Axel'
'Cema'	60[1]a	64[1] a	15[1] a	56[1] a	76[1] a	83[1] a
GiSelA 5	0 b	0 b	0 b	0 b	0 b	0 b
GiSelA 6	0 b	0 b	0 b	0 b	0 b	0 b

[1]: Multiple range test, α=0.05

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References

1. Anonym (2004) Ültetési anyagok és alanycsemeték követelményei, kötegelése és jelölése (Standard specifications of planting material and rootstocks, bundling, labelling). Magyar Közlöny (Hungarian Official Gazette). 57, 5899-5901.
2. Bujdosó G., Kállay E. (2004) Alany- és Fajtahasználat az európai cseresznyetermesztésben. (Use of rootstock and scion varieties in the European cherry growing) Kertgazdaság. 2, 55-64.
3. Bujdosó G., Hrotkó K., Stehr R., (2004) Evaluation of sweet and sour cherry cultivars on German bred dwarfing rootstocks in Hungary. Journal of Fruit and Ornamental Plant Research. 12,. 233-244.
4. Franken-Bembenek S. (1995) Vergleichende Darstellung der Versuchergebnisse mit Giessener Kirschenunterlagen. Erwerbsobstbau. 5, 130-140.
5. Franken-Bembenek S. (1998) GiSelA 5 (148/2) – dwarfing rootstock for sweet cherries. Act. Hort. 468 I. 279-283.
6. Franken-Bembenek S.(2004) Süßkirschen für kleine Gärten. Deutsche Baumschule. 1. 48-49.
7. Papp J. (1997). Művelési rendszerek (Growing systems). In Soltész M. (ed). Intengrált gyümölcstermesztés (Integrted fruit production). Mezőgazda Kiadó, Budapest, Hungary: 210-226.
8. Vogel T. (2001) Personal communication.

THE POLISH SYSTEM FOR THE PRODUCTION OF ELITE PLANTS OF POMOLOGICAL MATERIAL
AUGSTĀKO KATEGORIJU AUGĻAUGU STĀDU RAŽOŠANAS SISTĒMA POLIJĀ

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Kopsavilkums

Galvenās prasības: augu materiāls, kas pavairots tikai no elites vai sertificēta materiāla, ir bāzes vai sertificēts pavairošanas materiāls; materiāls, kas pavairots no vīrustestēta materiāla, ir vīrustestēts pavairojamais materiāls; augi tiek audzēti augsnē, kura brīva no *Globodera* spp. un *Synchytrium endobioticum*; elites un sertificēts *Prunus, Rubus* un *Fragaria* ģinšu materiāls tiek audzēts no *Longidorus* spp. un *Xiphinema* spp. nematodēm brīvā augsnē. Kandidātaugi tiek iegūti no selekcijas vai izlases materiāla, stādīti konteineros, kas nav saskarsmē ar nesterilizētu augsni, audzēti tīklu mājās, brīvi no EPPO shēmās minētajiem kaitīgajiem organismiem. Kokaudzētavā obligāti jāievēro telpiskā izolācija, šķirnes tīrība, ierobežots izmantošanas laiks, rekomendētās pavairošanas metodes un augu aizsardzības prasības.

Abstract

The general requirements concerning production and quality of nursery plant material of fruit tree and small fruit species are the following: fruit plant material propagated exclusively from elite or certified components is regarded as basic or certified nursery material; fruit plant material propagated from virus-tested components is regarded as virus-tested nursery material; nursery plantations shall be established on ground or in soil regarded as free of *Globodera spp*. and *Synchytrium endobioticum;* nursery plantations of elite and certified material of the genera *Prunus*, *Rubus* and *Fragaria* should be established on ground or in soil regarded as free of *Longidorus* spp. and *Xiphinema* spp. nematodes.

Reselected plants shall be divided from candidate plants of the same cultivars proven to be true – to type. Candidate plants usually descent from a breeding program or are selected trees from a group of trees of one cultivar. Plants should be planted in containers without contact of their roots with soil or in disinfected soil quarters protected by netting (carcasses). Plants should be indexed for the organism listed in Annex 1 and Annex 2.

Indexing should be periodically repeated by one of the methods recommended by the European and Mediterranean Organization for Plant Protection - EPPO.

Most important requirements for all fruit nursery material are following: spatial isolation, purity of species and variety (trueness to type), limited period of use, recommended method of propagation, health status – List of harmful organisms which reduce the quality of nursery plant material: pests, fungi, bacteria and viruses, Annex 1 and Annex 2.

Key words: pomological plant material, methods of propagation, spatial isolation, purity of species and clones, health status

Propagation system of plant material

In order to meet the needs for the production of elite nursery-propagated fruit-bearing plant material, it is essential to select the candidate plant from a group of trees (plants) of the same variety. The candidate plants can also come from a breeder or be obtained from foreign centres involved in the production of elite nursery plant material. The plants obtained are tested to determine if they are free from the organism listed in the annex to the Directive by the Ministry of Agriculture and Rural Development (Dziennik Ustaw, 2004; Jelkman, 2001; Nemeth, 1986).

Virus-tested material which has been tested and recognized as free of viruses, and also the material obtained directly from virus-tested material which is produced or maintained within the specified number of passages or multiplication cycles, have to be kept under conditions that guarantee absence of infection. To meet these requirements, plants should be grown in containers without the roots touching the soil, or in disinfected substrates and kept in rooms enclosed with wire netting (carcasses).

Testing shall be periodically repeated to check the state of plant health, by one of the methods recommended by the European and Mediterranean Organization for Plant Protection (EPPO), (Desvignes, 1999; Roy and Smith, 1994).

The general requirements concerning the production and quality of nursery plant material of fruit trees and small fruit plants are as follows:

- fruit plant material propagated from virus-tested components is regarded as basic or certified nursery material;
- fruit plant material which is propagated from virus-tested components is regarded as virus tested nursery material;
- nursery plantations shall be established on the ground or in the soil regarded as free from *Globodera* spp. and *Synchytrium endobioticum;*
- Nursery plantations of elite and certified material of genus *Prunus, Rubus* and *Fragaria* should be established on the ground or in the soil regarded as free of *Longidorus* spp. and *Xiphinema* spp. nematodes.

In Poland specific requirements have been developed for the nursery-propagated fruit-bearing plants, for fruit tree production, mother orchards for seeds and scion wood production, and for small fruit plantations, respectively:

- plantations of vegetatively propagated rootstocks for fruit trees;
- nurseries of generative rootstocks for fruit trees;
- mother orchards for seed plants;
- mother orchards for scion wood production;
- nurseries for fruit trees and plantations of budded rootstocks;
- mother plantations and runner plants of strawberry;
- mother plantations and nurseries of currants and gooseberry;
- mother plantations and nursery plants of raspberry and blackberry;
- mother plantations and nursery plants of blueberry and cranberry.

Detailed requirements concerning the production and quality of nursery plant material of fruit plants are as follows:

- recommended method of propagation and proposed grades for certification;
- spatial isolation;
- health status - List of harmful organisms which reduce the quality of nursery plant material: pests, fungi, bacteria and viruses;
- purity of species and varieties;
- age of mother orchards, mother plantations and nursery plant material;
- additional requirements;
- number and time of inspection;
- after observing irregularities which are corrigible, dates for additional inspection are proposed;
- each species, variety, rootstock and grade shall be labelled.

Detailed requirements for plantations of vegetatively propagated rootstocks for fruit trees

1. Spatial isolation:
   a) stock plantations of plants which can be affected by Plum pox virus shall be situated no closer than 500 m from wild plants or plantations of fruit bearing plants of the same genus;
   b) stock plantations of plants which cannot be affected by Plum pox virus shall be situated no closer than 10 meters from wild plants or plantations of fruit bearing plants of the same genus;
   c) virus-free stock plantations shall be situated no closer than 3 meters from other stock plantations;
   d) rootstocks of different clones shall be planted in separate rows, which includes also rootstocks of the same clone planted in different years.
2. Material for establishing basic nursery plantations shall be produced from pre-basic plants produced by micropropagation, cuttings or stoolbeds. Rootstocks dedicated for establishing mother plantations of pome species shall be no older than two years, for stone fruit species one-year-old shall be used. Material for establishing stock nursery plantations shall be derived from basic plantation or rootstocks certified as elite ones.
3. Purity of species and clones. For mother plantations complete clonal purity is required.

4. Period of use:
   a) basic plantations of pome species are maintained for up to 8 years, those of stone fruit species – only for up to 6 years;
   b) certified plantations of pome trees are maintained for up to 12 years, while those of stone fruit trees - for up to 10 years.
5. Health status

   Material for mother plantations of vegetative rootstocks shall be:
   a) free of organisms to be controlled;
   b) on the basis of visual evaluation – in practice free of organism that could reduce its quality, in particular organisms referred in Annex 1;
   c) virus diseases and virus–like diseases: rootstocks free of organisms referred in Annex 1 are regarded as free of virus diseases and virus-like diseases (Jones and Aldwinkle, 1997).
6. Additional requirements
   a) once a year, the plantation is presented for inspection – at the end of summer or at the beginning of autumn;
   b) after observing irregularities which are corrigible, dates for additional inspection can be proposed;
   c) each clone of rootstock shall be labelled at the beginning of row quarters.

Very similar requirements were accepted for nurseries of generative rootstocks for fruit trees.

Mother orchards for scion wood production

1. Spatial isolation
   a) orchards of plants which can be affected by Plum pox virus shall be situated no closer than 500 m from wild plants or orchards of fruit bearing plants of the same genus;
   b) orchards of plants which cannot be affected by Plum pox virus shall be situated no closer than 50 m from wild plants or orchards of fruit bearing plants of the same genus;
   c) orchards for scion wood production of different varieties of the same species shall be planted in separate rows, or in one row when spacing is no closer than 2 m;
   d) virus-free orchards for scion wood production shall be situated in different quarters maintaining an isolation distance of 50 m for trees of pome species and 500 m for trees of stone fruit species of the same species and genus from CAC category.
2. Purity of species and variety. Complete purity of species and variety are required.
3. Propagation – orchards for scion wood shoots shall be established from the elite trees dedicated for mother orchards for scion wood production.
4. Usage
   a) orchards for scion wood production of stone fruit trees will be maintained up to 6 years, while orchards of pome trees – up to 8 years;
   b) with the exception of stone fruits mother trees are allowed to bear fruit.
5. Health status
   a) free of organism covered by duty to fight against, which are an Annex 1;
   b) on the basis of visual evaluation – in practice free of organisms that could reduce its quality, in particular organisms referred in Annex 1;
   c) virus diseases and virus – like diseases: mother trees and scion wood free of pathogens referred in Annex 1 are regarded as free of virus diseases and virus – like diseases (Jones and Aldwincle, 1997; Ogawa *et al*., 1995).
6. Additional requirements sare the same as for vegetatively propagated rootstocks.

Nurseries for fruit trees and plantations of budded rootstocks

1. Spatial isolation
   a) nurseries of plants which can be affected by the Plum pox virus shall be situated no closer than 500 m from wild plants or orchards of bearing fruit plants of the same genus;
   b) nurseries of plants which can not be affected by Plum pox virus shall be situated no closer than 10 m from wild plants or orchards of fruit bearing plants of the same genus;
   c) elite nurseries for trees and plantations of budded rootstocks shall be situated no closer than 5 meters from certified mother plantations and CAC;
   d) nurseries of virus-free trees shall be situated no closer than 2 meters from other trees and the plantations of budded rootstocks.

2. Purity of species and variety. In nurseries for trees and plantations of budded rootstocks complete purity of species and variety are required. Trees with incompatibility symptoms (leaf drop, yellowing of leaves and discoloring of bark) are distinguished.
3. Propagation – nurseries shall be established from the elite or certified material dedicated for nurseries.
4. Age. Elite trees shall be no older than 2 years. Certified trees shall be no older than 4 years of age
5. Health status
   a) free of organisms covered by duty to fight against;
   b) in practice free of organisms that could reduce its quality – organisms referred in Annex 1;
   c) free of virus diseases and virus-like diseases – pathogens referred in to Annex 1;
6. Additional requirements are the same as for vegetatively propagated rootstocks. Mother plantations and runner plants of strawberry:
1. Propagation. Material for the establishment of basic nursery plantations shall be propagated from pre-basic plants produced by micropropagation or runner plants. For strawberry four certification grades are used:
   a) super elite (SE) – pre basic material;
   b) elite 1 and elite 2 (E1, E 2) – basic material;
   c) original (O) certified material.
2. Spatial isolation
   a) basic plantations shall be situated no closer than 200 m from wild plants or plantations of fruit bearing plants of the genus *Fragaria spp*.– while certified plantations – no closer than 50 m;
   b) distance between varieties, certification grades or categories in plantations shall be no smaller than 3 m.
3. Purity of species and variety. Complete purity of species and variety are required
4. Age. Plantations of strawberry may be maintained up to 1 year. On land dedicated for strawberry: no strawberry, potato cucumber tomato, flax, currant bush, gooseberry, raspberry or blackberry is allowed to be planted for at least 4 years prior to the establishment of the plantation.
5. Health status – mother plants and runner plants of strawberry shall be:
   a) free of organisms covered by duty to fight against, which are an Annex 2;
   b) on the basis of visual evaluation – in practice free of organisms that could reduce its quality, in particular organisms referred in Annex 2 and the following ones: viruses and virus – like pathogens see Annex 2.
6. Additional requirements
   a) once a year the plantation is inspected, which is performed in summer or in autumn before lifting the plants or before sale of potted plants, other requirements in point b and c are similar as for vegetatively propagated rootstocks;
   b) similar requirements are recommended for mother plantations of currants, gooseberry, raspberry, blackberry, blueberry and cranberry.

Annex 1

List of harmful organisms which reduce the quality of nursery – garden material -minimum requirements for CAC nursery material.

Free of organism covered by duty to fight against as below:

Apple *(Malus* Mill.*)*.

1) pests:
   a) peach twig borer (*Anarsia lineatella)*;
   b) *Eriosoma lanigerum;*
   c) aspidiotuses *(Quadraspidiotus perniciosus, Epidiaspis leperii, Pseudaulacaspis pentagonai);*
2) bacterial diseases:
   a) root nodosity (*Agrobacterium tumefaciens);*
   b) bacterial cancer (*Pseudomonas syringae pv. syringae);*
3) fungal diseases:
   a) honey fungus (*Armillariella mellea);*
   b) *Chondrostereum purpureum;*
   c) cancer of fruit trees (*Nectria galligena);*

d) ring rot of trunk base (*Phytophthora cactorum);*
e) white fusarial rot of roots (*Rosellinia necatrix);*
f) scab (*Venturia* spp.*);*
g) verticillium wilt (*Verticillium* spp.).

4) virus diseases and virus-like diseases – all.

Such material shall be free of any viruses and virus-like pathogens, in particular the following ones and is labelled as: *vf – virus-free*

1) apple:

a) *Apple chlorotic leafspot virus*,
b) *Apple mosaic virus,*
c) *Apple stem grooving virus*,
d) *Apple stem pitting virus*, causing spy epinasty and decline,
e) *Apple proliferation phytoplasma*,
f) Apple chat fruit,
g) Apple green crinkle,
h) Apple horseshoe wound,
i) Apple rough skin,
j) Apple star crack,
k) Apple ring spot,
l) Apple russet ring,
m) Apple rubbery wood,
n) Apple flat limb,
o) Apple russet wart,
p) Platycarpa scaly bark;
q) Spy epinasty and decline

Annex 2

Health status - mother plants and runner plants of strawberry shall be:
Free of organisms covered by duty to fight against as below:
List of organisms which reduce the quality of the nursery – material minimum requirements CAC
Strawberry *(Fragaria x ananassa* Duch*)*.

1) pests:

a) nematodes (*Aphelenchoides* spp.),
b) potato stem eelworm (*Ditylenchus dipsaci)*,
c) *Tarsonemidae,*

2) fungal diseases:

a) rot of strawberry crown (*Phytophthora cactorum)*,
b) verticillium wilt (*Verticillium* spp.)

3) virus diseases and virus - like diseases: *Strawberry green petal phytoplasma MLO*, one the basis of visual evaluation – in practice free of organisms that could reduce its quality, in particular organisms referred in Annex 2 and the following ones:

- viruses and virus-like pathogens:

Arabis mosaic virus,
Raspberry ringspot virus,
Tomato black ring virus,
Strawberry crinkle virus,
Strawberry latent ringspot virus,
Strawberry mild yellow edge virus,
Strawberry mottle virus,
Strawberry vein banding virus,
Strawberry green petal phytoplasma,
Aster yellows phytoplasma,

and pathogens causing strawberry june yellows,

- diseases:

rot of strawberry crown (*Phytophthora cactorum*);
verticillium wilt of strawberry (*Verticillium dahliae*);

anthracnose *(Colletotrichum* spp.*);*
leaf – spot of strawberry (*Mycosphaerella fragariae*);
powdery mildew of strawberry (*Sphaerotheca macularis ssp. fragariae*);
red leaf – spot of strawberry (*Diplocarpon earliana).*

- pests:
Meloidogyne spp.;
potato stem eelworm (*Ditylenchus dipsaci*);
chrysanthemum nematode (*Aphelenchoides ritzemabosi*);
strawberry nematode (*Aphelenchoides fragariae*);
strawberry mite (*Phytonemus pallidus ssp. Fragariae*);
aphids (*Aphididae);*
leafhoppers (*Jassidae);*
thrips *(Thripidae);*
common red spider *(Tetranychus urticae).*

References

1. Desvignes, J.C. (1999) Virus Diseases of Fruit Trees. Ctifl (Centre technique interprofessionnel des fruits et legumes) 22, rue Bergere 75009 Paris.
2. Dziennik Ustaw z dnia 8 marca 2004, Nr 5, poz. 565, załącznik No 9. 2004. Szczegółowe wymagania dotyczące wytwarzania i jakości materiału szkółkarskiego roślin sadowniczych i winorośli.
3. Jelkmann, W. (2001) Recommendations for pathogen detection. Proceedings of the 18th International Symposium on virus and virus-like Disease of Temperate Fruit Crops. Ed M.F. Clark, Acta Hort. 550, vol.2, 471-493
4. Jones, A.L. and H.S. Aldwincle. (1997) APS Press. Compedium of Apple and Pear Diseases. The American Phytopathological Society.
5. Nemeth, M. (1986) Virus, Mycoplasma and Rickettsia Diseases of Fruit Trees. Martinus Nijhoff Publishers, Dordrecht, The Netherlands.
6. Ogawa, Ed.J.M., E.J. Zehr, G.W. Bird, D.F. Pitchie, K. Urin and J.K. Uyemoto. (1995) Compedium of Stone Fruit Diseases. APS Press. The American Phytopathological Society
7. Roy, A.S. and J.M. Smith. (1994) Plum pox situation in Europe. EPPO Bull, 24, 515-523
8. Smith I.M., D.G. McNamara, P.R. Scott and K.M. Harris (1992) Quarantine pests for Europe. Data sheets on quarantine pests for the European Communities and for the European and Mediterranean Plant Protection Organization. CAB International, Wallingford, UK, and European and Mediterranean Plant Protection Organization, Paris, France

POSSIBILITIES OF IMPROVING METHODS OF VEGETATIVE PROPAGATION FOR CURRANTS
UPEŅU VEĢETATĪVO PAVAIROŠANAS METOŽU UZLABOŠANA

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Kopsavilkums
Laika posmā no 2001. līdz 2004. gadam Balkānu kalnu centrālajā daļā, Trojanas zinātniskajā institūtā tika ierīkotas sertificēta, no vīrusbrīva materiāla, mātesaugu stādījums šķirnēm `Ometa`, `Silvergieters Schwarze`, `Titania`, `Hedda`, `Lisil`, `Ben Lomond`, `Ben Tirran`, `Ben Moor` un `Ben Sarek`; kā arī Krievijas šķirnēm `Ņeosipajuščijsja` un `Bogatir`. Tika izmēģināti trīs upeņu pavairošanas veidi: lapainie spraudeņi, daļēji pārkoksnējušies spraudeņi un koksnainie spraudeņi. Labākie rezultāti tika iegūti upenes pavairojot ar koksnainajiem spraudeņiem. Lapaino spraudeņu apsakņošanai bija nepieciešams ilgāks laika periods.

Abstract
The revived interest in currant (*Ribes*) species in Bulgaria has imposed the need of range of cultivars enrichment as well as of mass production of planting material. From 2001 to 2004, through import of certified planting material from Germany, basic stoolbeds were established in the Research Institute at Troyan, located in the central region of the Balkan Mountains, and experiments on rooting of soft, semi-hardwood and hardwood cuttings were carried out. The stoolbeds contained initial virus free (VF) imported plants of the following cultivars black currants – Ometa, Silvergieters Schwarze, Titania, Hedda, Lisil, Ben Lomond, Ben Tirran, Ben Moor and Ben Sarek; as well as selected, virus tested forms of Biryulevskaya, Neosipayushchiyasya and Bogatir black currants**.** From rooting experiments the best results were obtained with hardwood cuttings. Rooting of soft cuttings was rather long lasting and hence this method proved ineffective.

Key words: black currant, red currant, propagation, planting stock, cuttings, certificate.

Introduction

The region located in the Central Balkan Mountains is suitable for growing of the small fruit species. Thanks to their rich chemical composition they present a valuable food for humans. They also possess distinct medicinal properties due to the contents of various vitamins, organic acids, antioxidants, etc. (Georgiev *et al.*, 2005). Recently, in Europe as well as in Bulgaria, there has been a growing interest in dark coloured small fruit species, such as black chokeberry (*Aronia melanocarpa L.*), black currant (*Ribes nigrum L.*) and blueberry (*Vaccinium carymbosum L.*) (Anon, 1996; Bielenin *et al*, 2002; Misic and Nikolic, 2003). This has lead to the need of enriching the range of cultivars and implementing mass scale production of planting material.

In 2001, through the Bulgarian-German project FAMAD, the Research Institute of Mountain Stockbreeding and Agriculture in Troyan, imported VF plants of 9 black currant and of two red currant cultivars. They were used for establishment of the demonstrative plantation as well as of basic stoolbeds. The objective of this study was to evaluate effiiency rooting of cuttings of currants, at different levels of maturity.

Materials and methods

The experiments were conducted from 2001 to 2004 at the Experimental Field of the Research Institute of Mountain Stockbreeding and Agriculture at Troyan, located in the central region of the Balkan Mountains. The cuttings were procured from the 0.1 ha demonstrative plantation of black currant (*Ribes nigrum L.*), cultivars Ometa, Hedda, Silvergieters Schwarze, Lisil and Titania, and from the 0,5 ha basic stoolbed plantation, including the cultivars Titania, Ben Lomond, Ben Moor, Ben Sarek and Ben Tirran. Other black currant cultivars used were Biryulevskaya, Bogatir and Neosipayushchiyasya, which are widely spread in this region.

Rooting was conducted outdoors and in polyethylene tunnels, in a light soil substrate prepared in advance from equal parts of sand, perlite, soil and peat moss of pH 4.5-5. Within two successive years four series of rooting were carried out, using cuttings of different maturity.

Trial 1: In August 2002 semi-hardwood cuttings, prepared of current year shoots, were rooted. Their preparation included cutting of only two buds (10 cm) and treatment with NAA (naphtalene acid) and IBA (indole butyric acid) at 50 ppm over a 24-h period in both. Spacing was 10×10 cm.

Trial 2. Cuttings were prepared in November 2002, according to a conventional technology; 20 cm long, laid tilted in the soil substrate with one bud above the surface. Spaced at 15×70 cm.

Trial 3. Rooting started in the second half of June 2003, with cuttings prepared of juvenile (green) shoots, 10 cm long. They were placed into the substrate, leaving two nods above the soil surface and reducing blades of adjacent leaves to one third.

Trial 4. Rooting in November 2003, applying the same technology as used for hardwood cuttings autumn of 2002.

Cuttings taken from different parts of shoots (basal, middle or terminal) were compared. The following parameters were recorded: percentage of rooting, height of the plants obtained diameter of the root collar, root length.

Results and Discussion

The results of summer rooting of semi-hardwood cuttings were consistent and depended on the used part of shoot (Fig. 1).

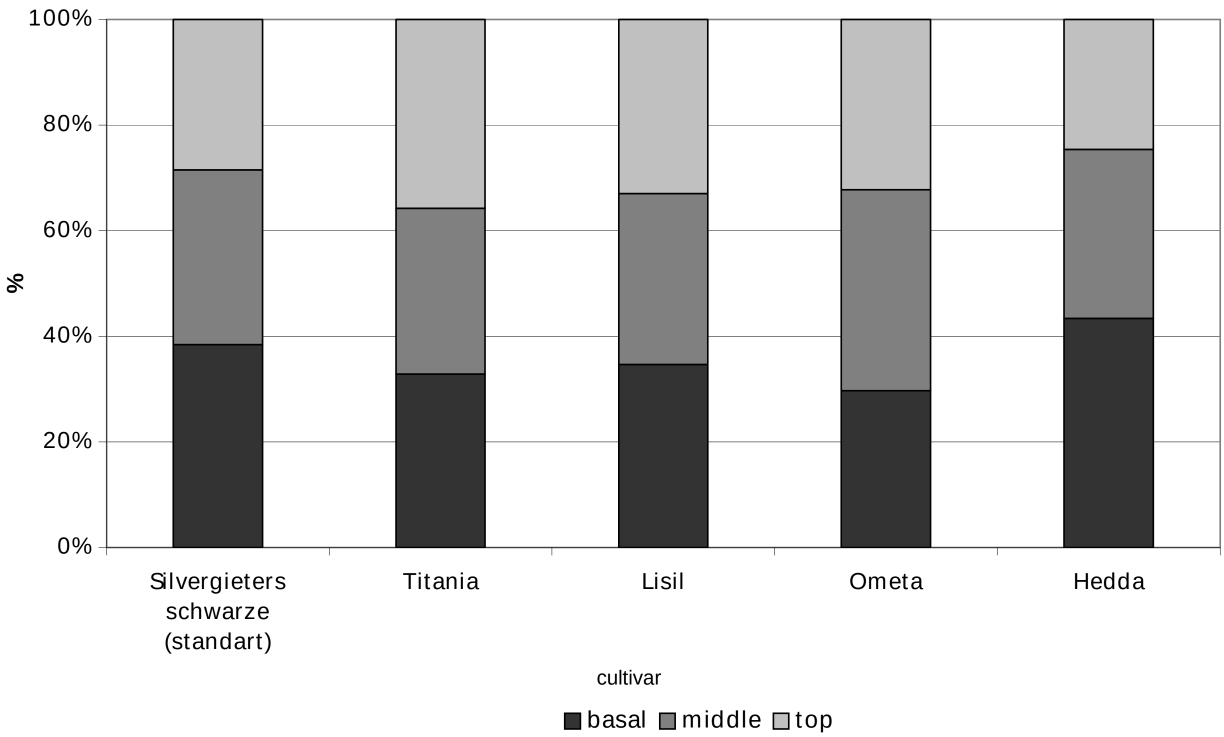

Figure 1. Percentage of rooted cuttings with origin from different parts of the shoots

The percentage of rooting of four black currant cultivars varied within a wide range, from 52.6% to 96.7%. The cultivar ‘Lisil’ showed the highest rooting percentage – 96.7%, when tip cuttings were used. The basal and middle parts were weaker - 86.1% and 74.2%, respectively. ‘Titania’ and ‘Hedda’ performed well when cuttings originated from the basal parts of the shoots. In the former cultivar the differences between the separate fractions were negligible, within 2-3%, while in the latter they reached 40% (when using tip cuttings).

Only in cv. 'Ometa' the cuttings prepared from the middle parts of the shoots rooted better, resulting about 11% higher than those made of the apical parts or about 16% higher than those made of the basal parts (Table 1).

Table 1. Confidence level of differences by (χ^2) between the percentages of rooting of the shoots obtained from different parts of the shoot

Cultivars	Basal/middle	Basal/top	Middle/top
Silvergieters Schwarze (standart)	++	+++	+
Lisil	ns	---	---
Titania	ns	ns	ns
Ometa	--	ns	--
Hedda	+++	+++	ns
total	++	+++	ns

P<0.05 - + (-) P<0.001 - +++ (---)
P<0.01 - ++ (--) ns – not significant

The lack of any regularity concerning the use of different parts of semi-mature shoots for preparation of cuttings leads to the conclusion that this method can be successfully implemented in all cultivars, when necessary, but only for the cv. 'Lisil' the rooting percentage was economically justified. Results of the second trial demonstrated that for the cuttings prepared during the dormant season (November) of the same year, the rooting percentage exceeded 95%, and the planting material obtained in late 2003 from the two rooting methods (semi-hardwood and hardwood cuttings) was of similar size, both in the aerial part and the root system. The advantage of rooting in August is a chance of using shorter cuttings; hence nearly twice-smaller number of shoots is needed.

The initial diameter of cuttings influenced to a large extent the growth of plants and quality of their root system.(Table 2).

Table 2. Effect of diameter of cutting and treatment with growth regulators on the size of plants obtained and the length of their root system in the experiments for rooting of hardwood cuttings

Treatment	diameter of cutting, mm	cv. Biryulevskaya			cv. Bogatir			cv.Neosipayushchiyasya		
		h [1], cm	d [2], mm	lenght of roots, cm	h [1], cm	d [2], mm	lenght of roots, cm	h [1], cm	d [2], mm	lenght of roots, cm
IBA	<5	38	8.9	30-40	-	-	-	29	6.7	20-30
NAA	<5	24	6.6	30-40	-	-	-	26	6.2	20-30
untreated	<5	29	6.4	20-30	-	-	-	30	7.1	20-30
IBA	5-10	36	8.3	30-40	18	6.6	20-30	29	7.3	20-30
NAA	5-10	26	8.1	30-40	16	6.5	20-30	32	7.8	20-30
untreated	5-10	29	6.9	30-40	20	6.4	20-30	31	7.3	20-30
IBA	>10	29	8.9	30-40	16	7.6	20-30	41	8.7	30-40
NAA	>10	21	6.9	20-30	-	-	-	48	8.9	30-40
untreated	>10	29	8.0	20-30	21	8.3	30-40	26	6.7	20-30

h–height of plants; d–diameter of plants, at root collar

In the three fractions (below 5 mm, 5-10 mm and over 10 mm) of cuttings from cv. Biryulevskaya not treated with growth regulators, plants of similar height (29 cm), were obtained. The root system of the medium thickness fraction was of the best quality. In cv. Neosipayushchiyasya, the thickness of root collar was the greatest when fraction of 5 to 10 mm was used for preparation of cuttings, followed by the of <5 mm and the lowest for the fraction exceeding 10 mm. In this cultivar the root system had nearly the same quality and size of about 20-30 cm, regardless of the fraction used. The plants produced from the fraction thicker than 10 mm reached the greatest height and diameter values.

The effects of the growth regulators differed in the three cultivars used in the experiment. For instance, the treatment of cv. Biryulevskaya with IBA produced better results than that with NAA, while in cv. Neosipayushchiyasya, better performance was noted with the NAA treatment of the fractions 5 to 10 mm and over 10 mm. In the trials with rooting of soft cuttings the results obtained were poor due to the extremely high temperatures and the failure to ensure optimal air humidity in the tunnels. This method of rooting is not economically justified, as the plants were ready to transplantation only in the second year. It can be applicable, though, in case of insufficient mother plant stock, when from a small number of stock plants cuttings may be collected many times.

Conclusions

The most appropriate method for rooting of black currant, both in special facilities and outdoors, with or without use of growth regulators, is the rooting of hardwood cuttings.

Plants with the best-developed root system are obtained when cuttings of the middle part of the shoots are used, while the quality of cuttings from the other parts of the shoot may be improved by implementing growth regulators.

The diameter of a cutting exercises a marked impact on the quality of the planting material, but if growth regulators are applied, the quality of plants obtained is uniform.

Rooting of soft cuttings is pointless without ensuring artificial mist and shading during hot-summer days.

In case of extremely high demand for planting material all the methods discussed above could be implemented for full-scale utilisation of the available basic stoolbeds.

References

1. Anon (1996) 50 godina Centra za vocarstvo i vinogradarstvo, Cacak. Instutute za istrazivanja u poljoprivredi SRBIJA, Birografika, Subotica.
2. Bielenin A., Gajek D., Gwozdecki J., Lisek J., Labanovska B., Mochecki J. and Niemczyk E. (2002) Integrowana Produkcja Owocow-Porzeczki, ISiK, Skierniewice.
3. Georgiev D., Dinkova H. and Mihaylova P. (2005) Growth and fruit bearing of some cultivars of black currant and red currant, with erosion control soil pre-planting preparation. In: Management, Utilization and Preservation of Soil Resources. Proc. of the National Conference with International Participation Publish Scieset-Eco, Sofia, Bulgaria, 207-209.
4. Misic P. D. and Nikolic M. D. (2003) Jagodaste vocke, Instutute za istrazivanja u poljoprivredi SRBIJA, Jures, Cacak.

EXPERIENCE IN ESTABLISHING A SCIONWOOD ORCHARD IN THE CENTRAL BALKAN MOUNTAINS IN BULGARIA
POTZARU MĀTESAUGU DĀRZA IERĪKOŠANA BALKĀNU CENTRĀLAJĀ DAĻĀ BULGĀRIJĀ

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Kopsavilkums
Trojanas institūtā Bulgārijā 15 gadu garumā tiek veikti pētījumi par vīrusbrīva plašāk audzēto augļaugu sugu potzaru mātesaugu stādījuma ierīkošanu un uzturēšanu. Pirmie izmēģinājumi tika veikti ar plūmju šķirņu mātesadārza ierīkošanu. Tika izstrādāti nosacījumi telpiskās izolācijas ievērošanai, vektoru kontrolei un testēšanas sistēmai. Stādījumā iegūti saimnieciski nozīmīgi vīrusbrīvi plūmju šķirņu potcelmi. 2000. gadā Bulgārijas - Vācijas zinātniskā projekta ietvaros tika ierīkots kopīgs izmēģinājums septiņu augļaugu sugu, vīrusbrīva potzaru mātesdārzu izveidošanai. Šis dārzs nodrošina potcelmu pieprasījumu Bulgārijas ziemeļu daļas stādu audzētavām. Rakstā ir apkopota informācija par izmantotajām metodēm.

Abstract
Over a 15-year period a research team of the Research Institute of Mountain Stockbreeding and Agriculture (RIMSA – Troyan) has conducted experiments focused on possibilities of establishing and maintaining virus free (vf) scionwood orchards, comprising samples of the main fruit species of our country. The first attempts were aimed at setting up plum scionwood orchards. For that purpose the main technological parameters were elaborated, related to space isolation, vector control and re-testing systems. As a result, a scionwood orchard was established and managed, providing vf scions of plum cultivars of practical value. On the grounds of these preliminary studies and in connection with the need for introducing the European directives and certification schemes in the production of planting material, in the year 2000 RIMSA – Troyan launched a large scale Bulgarian-German project for establishing scionwood orchards for vf and vt scions of seven fruit tree species, regarded as promising in our country. The orchard has been utilised ever since and it has provided scions for nursery owners in Northern Bulgaria. The paper summarizes the results concerning effectiveness of the implemented technologies.

Key words: fruit trees, virus free, virus tested, planting material, scionwood orchard, certification.

Introduction

The Fruit-Growing Department at the Research Institute of Mountains Stockbreeding and Agriculture (RIMSA) in Troyan has a 15-year long experience in monitoring and control of the sanitary status of fruit planting stock. From 1989 to 2001 a plum scionwood orchard was maintained in the area called Draganovoto that provided the Institute and the nearby nurseries with scions of the virus tested (vt) category (Dragoyski *et al*., 2004).

In connection with implementing of certification of fruit tree planting stock in Bulgaria, in 2000 a German-Bulgarian pilot project got under way. It included the setting up of four scionwood orchards for certified vf and vt scionwood at RIMSA, Troyan, in the Fruit Growing Institute – Plovdiv, the Agricultural Institute in Kyustendil, and in the Regional Centre of Peach Crop, Sliven. Establishing of these orchards complied with the European Directive and the applicable EPPO recommendations for the production of vf and vt propagation material (Anon, 1992; EPPO 1991, 1992a, 1992b, 1992c; Barba, 1998). In conformity with these documents the new Act for Seed and Planting Material as well as all regulatory documentation related thereto were developed and enforced (Anon, 2004). Throughout the period mentioned the essential technologies have been developed for establishing, maintenance, inspection and control of the health status and production of fruit tree planting material.

Materials and Methods

For establishing of a scionwood orchard, a site was chosen, meeting the requirements of Bulgarian legislation (Anon, 2004), isolated by a 1000-m distance from existing orchards. The orchard is located within an oak-tree forest complex, at 800 m.a.s.l., in the Central Balkan Mountains. The soil is light grey-brown podsolic, forest type, slightly eroded, developed on carbonate-free soil maternal rock. Soil profile is about 150-170 cm deep, clearly differentiated. The soil is slightly to highly acid, with values of pH_{KCl} ranging from 3.7 to 5.2 along the profile depth. The humus content is medium (3.67%); the soil is well supplied with total nitrogen (0.22%) and total phosphorus (0.19%) and shows rather low available K content (11.6 mg per100 g). The annual average temperature is 9.2ºC, and the average annual rainfall above 800 mm (Mikhaylova, 2000).

The preparation of the site for the new scionwood orchard started in 2000 with clearing of the wildlife vegetation, of the genuses *Prunus, Malus, Cydonia, Crataegus* and others, hosting viral or some hazardous fungal and bacterial diseases. Their control was accomplished through uprooting and herbicide application. Soil samples were analysed for the presence of nematodes. Deep ploughing was performed at the 0.1-ha site in autumn. In spring of the next year (2001) 30-cm deep trenches were marked and open in rows spaced at 4 m. The trenches were filled with well decomposed manure (35 kg per meter, at 50% moisture content) and combined fertiliser N:P:K - 15:15:15 (at a rate of 100 g per meter). After the trenches were closed, 1-m wide row strips were marked. The orchard has been maintained without irrigation.

In order to avoid infections, the scionwood orchard was established through *in situ* budding on vf rootstocks imported from Germany.

The orchard floor in the 3 m wide alleyways were grassed down, while along the rows strips, 1 m wide strips were maintained clean, by digging and mulching with grass cut from the interrow alleyways. These measures limited growth of broad-leaved weeds – secondary hosts of migrating aphid species, vectors of phytopathogenic viruses. An intensive chemical aphid-control was made.

The scionwood orchard has been inspected at least three times throughout every growing season for any symptoms of viral or virus-like infections (Dragoyski, 1999; Minev, 2004). ELISA testing is carried out for any economically important viral diseases: ACLSV (Apple chlorotic leaf spot trichovirus), ApMV (Apple mosaic virus), PDV (Prune dwarf virus), PNRSV (*Prunus* necrotic ring spot virus) and PPV (Plum pox potty virus). A system was elaborated in order to ensure that each tree has been tested once over a three-year period. Trees that manifested symptoms suspected of viral infection were subjected to mandatory tests. The infected trees were uprooted. In order to prevent any mechanical transfer of viral infection during pruning, the tools were disinfected with alcohol after pruning of each tree.

Results and Discussion

The rootstocks were planted in early March 2001 and were inoculated on 10 August in the same year with 20 apple, 7 pear, 11 plum, 3 apricot, 7 peach, 7 sweet cherry and 5 sour cherry cultivars.

T budding and chip-budding was applied, with two buds put on each rootstock. In October 2001 a high percentage (94%) of bud take was recorded for all fruit species. Nevertheless, in spring of the following year a considerable number of buds of the thermophile species (peach, cherry and apricot) were found dead, apparently damaged by low temperatures in the wintertime. These fruit species were frost killed in the successive years. In spite of the numerous attempts to bud them again in 2002, 2003 and 2004, scion shoots were notoriously killed by winter frosts. The following cultivars proved relatively winter hardy: apricot – Luizet, Hungarian best and Tyrinthos; cherry – Van and Sylvia; peach – Flavour crest. The low percentage of successful budding could be partially overcome through planting of ready purchased trees. These facts proved that scionwood orchards with such fruit species should be established in regions that correspond to their agrobiological requirements.

Formation of the scionwood trees lasted until the beginning of 2004. Initially, out of the two sprouting scion shoots one was selected, that was better developed and was trained as a stem. It was then headed back when reached a height of 60-80 cm. The more poorly developed (second) sprout was pruned before that and utilised as scionwood.

In the third year, about four lateral shoots were derived per tree, while the basal 50-cm part of the stem was left as a trunk. Pruning in the fourth year consisted in reducing the shoots to two buds – in case of shoots showing moderate or week growth or to 4-6 buds – in case of the more vigorous and straight. More moderate pruning of vigorous shoots is necessary in order to prevent later development of premature secondary (sylleptic) shoots, which are useless as scionwood.

The number of scionwood obtained per tree per year increased progressively and in 2004 it reached 10 scions per tree, on an average (Table 1).

Table 1. Scionwood of different fruit species obtained in the years 2002-2005

Fruit species	Number of cultivars	Number of trees	Scionwood obtained in successive years			
			2002	2003	2004	2005
Apple	20	658	1000	2800	6000	6500
Pear	7	200	250	800	1600	2000
Plum	11	794	1000	3200	5000	7000
Peach	7	331	100	100	70	70
Sweet cherry	16	195	250	800	1000	800
Sour cherry	6	70	70	300	700	700

A key aspect for achieving balance in each tree was determining the optimal number of buds left on the shoots, corresponding to the vigour of each tree and particular shoot. Whenever the tree is "loaded" with a low number of buds, too vigorous premature shoots will grow that are unsuitable for propagation and *vice versa* – leaving too many buds will result in weak shoots that produce poor quality scionwood.

Another important point to consider is that yielding too high number of scions will exhaust trees due to the sharp reduction of the assimilating surface; then wood is incapable to reach a proper maturity and thus remains susceptible to low temperature injury. Thus, following a large-scale yield of scions in the summer of 2004, and the extremely low temperatures in January and February of 2005, a considerable winter killing was noted in the stone fruit species (cherry, plum, apricot and peach). Therefore, in order to prevent frost injury to the trees, at summer pruning for collection of scionwood, 1-2 unpruned shoots should be left.

Based on our experience so far, two kinds of pruning in the scionwood orchards may be distinguished:

- summer pruning for scionwood procuring;
- winter pruning, aimed at provoking growth of new shoots and removal of the fruit buds; in the scionwood orchards for vf scion material, flowering should be eliminated, taking into account viral diseases transmitted by pollen.

Scionwood was commercialised first in 2002. The price was calculated on the basis of direct costs per one bud and it amounted to € 0.1 in the first year, in the second – € 0.08 and in the third one – € 0.06.

Conclusions

The regions located in the Central Balkan Mountains, at the altitude of 600-800 m and guaranteed spatial isolation of 1000 m from existing orchards are suitable for establishing of orchards for production of certified scionwood. These conditions preclude the spread of viral infections, but there bring risks of frost damage to thermophylic fruit species.

The high cost of the scionwood obtained in such orchards is a limiting factor for formation of attractive prices for nurserymen. That is why this kind of production should be subsidised by state or trade branch organisations.

Production of certified scionwood requires proper experts and laboratory base. Therefore, it should be carried out by state or private organisations that have properly prepared personnel.

References

1. Anon. (1992) European Community Council Directive 92/34 of 28 April 1992 on the marketing of fruit plant propagating material and fruit plants intended for fruit production. EC Bulletin n. L 157/10 of June 10, 1992.
2. Anon. (2004) Ordinance No.40 of the Ministry of Agriculture and Forestry of Bulgaria, dated 30.09.2004, On regulating the production of and trade with fruit tree species planting material, SG issue 93 dated 19.10.2004.

3. Barba M. (1998) Virus certification of fruit tree propagative material in Western Europe, plant virus disease control, APS Press, St. Paul, Minesota, USA, 288-293.
4. Dragoyski K. (1999) Possibilities of production of scions and stones for virus free planting material production of plum and myrobalan. Journal of Mountain Agriculture on the Balkans, 2 (5), 531-544.
5. Dragoyski K., Minev I. and Dzhuvinov V. (2004) A strategy to bring under control the losses of sharka in Bulgaria. Vangdal. E. (ed.) The 8th International Symposium on Plum and Prune Genetics, Breeding and Pomology, Lofthus Norway, Book of Abstracts, 52.
6. EPPO (1991) Certification scheme. Virus-free or virus tested fruit trees and rootstocks. Part I: basic scheme and its elaboration. EPPO Bulletin, 21, 267-277.
7. EPPO (1992a) Certification scheme. Virus-free or virus tested fruit trees and rootstocks. Part II: tables or viruses and vectors. EPPO Bulletin, 22, 255-263.
8. EPPO (1992b) Certification scheme. Virus-free or virus tested fruit trees and rootstocks. Part III: testing methods for viruses of fruit trees present in the EPPO region. EPPO Bulletin 22, 265-275.
9. EPPO (1992c) Certification scheme. Virus-free or virus tested fruit trees and rootstocks. Part IV: technical appendices and table of contents. EPPO Bulletin, 22, 277-283.
10. Minev I. (2004) Sharka tolerant plum hybrids. Journal of Mountain Agriculture on the Balkans, 7, 51-60.
11. Mihaylova, P. (2000) Erosion leaching of basic soil components with some forage crops grown on light grey (pseudopodzolic) forest soil. PhD Thesis, Institute of Soil Science"Nikola Pousharov", Sofia, 33-38.
12. Law for seed and Planting Material Act. SG, No 20 of 04.03.2003.

THE QUALITY OF ROOT SYSTEM OF DWARF ROOTSTOCK 'PUMISELECT' FOR PEACH TREES
PERSIKU SAKŅU SISTĒMAS KVALITĀTE UZ PUNDURPOTCELMA 'PUMISELECT'

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Kopsavilkums

Pumiselect® ir *Pumiselect pumila* dzimtas klona potcelms persikiem un aprikozēm. Izmēģinājumā no 2002 līdz 2004 gadam tika pētītas šī potcelma pavairošanas iespējas, izmantojot koksnainos spraudeņus. Rudenī tika nogriezti pārkoksnējušies viengadīgie dzinumi, 40 cm garumā. Tie tika kalibrēti pēc diametra divās grupās: > 5 mm un < 5 mm. Puse no katras diametra grupas tika apstrādāti ar apsakņošanos veicinošo naftiletiķskābi (NES). Pavasarī spraudeņus stādīja kokaudzētavā 20 cm dziļumā un vasarā uzacoja šķirnes. Rudenī sakņu sistēmas kvalitāte novērtēta kā laba. Ne spraudeņu diametram, ne apstrādei ar apsakņošanās stimulatoru nebija nozīmīgas ietekmes uz sakņu masu. Tievākajiem spraudeņiem, apstrādātiem ar NES, bija vērojams mazāk sakņu aizmetņu un saknes vairāk bija attīstījušās spraudeņa lejasdaļā. Resnākajiem spraudeņiem bija spēcīgāka virszemes daļa.

Abstract

Pumiselect® is a clonal *Pumiselect pumila* rootstock for peach and apricot. The aim of an experiment conducted in 2002-2004 was to determine the ability of Pumiselect propagation by hardwood cuttings. In autumn from one-year-old hardwood shoots 40 cm long sections were cut. The hardwood cuttings were calibrated into 2 groups according to the diameter: > 5 mm and < 5 mm. In each group of hardwood cuttings, 50% of them were treated with rooting stimulator with 0,5% NAA. In the spring, hardwood cuttings were planted in the nursery 20 cm deep. In the year of planting, the rootstocks were budded. In the autumn, the quality of root system was estimated.

The quality of the root system was very good. Both diameter of cuttings and rooting stimulator didn't have an influence on the root mass. The hardwood cuttings > 5 mm of diameter and treated with NAA had the least number of places with outgrowing roots and the least roots in the highest part of rootstock. The thicker hardwood cuttings promoted the overhead part of rootstock.

Key words: peach, rootstock, Pumiselect®, hardwood cuttings, root system

Introduction

The peach is a very attractive fruit for customers, due to high savory and dietetic value as well as high worth for different fruit products. Poland produces 8-10 thousand tons of peaches. Home products provide 10% general consumption of peach -2,5 kg per one person (Kubiak 2001).

The small production of peach in Poland results from the lack of optimal climatic conditions for the cultivation of this species. Peach can grow in regions with average yearly temperature + 8 °C and with the sum of active temperatures 2500°C, during the vegetative season. The principal factor, which limits the cultivation of peach, is the minimal temperature in the winter and spring frosts. In the winter thestem of the tree, its branches and shoots are destroyed in -25 °C. Flower buds of peach are frozen at -20 °C temperature (Radajewska and Pisarska, 1994). In the spring, 10-90% flower buds are destroyed by spring frosts of -2 to -4 °C temperature (Treder, 2001). Therefore the peach orchards are planted above all in the southwestern part of Poland.

In Poland the fruit growers have also a problem with an intensification of peach cultivation, due to the lack of dwarf rootstock for this species. The peach trees are produced on seedling rootstocks originating from *Persica vulgaris* (*P. mandshurica*, *sibirica*, *Rakoniewicka seedling*) and were planted at wide aplanting distance. For that reason, in many countries all over the world, the experiments with dwarf rootstocks for peach trees are carried on. Research are conducted with *Prunus bessey* and *Prunus pumila* (Szewczuk, 2000)

Rootstock Pumiselect® is a clonal *Pumiselect pumila* rootstock for peach and apricot and was selected by Prof. F. Jacob in Geisenheim Institute. In USA this rootstock is tested in many experiments as 'Rhenus 2'. The preliminary results suggest that Pumiselect® belongs to dwarf or semi-dwarf rootstock. The vegetative growth of peach on this rootstock is 65% smaller than those budded on Nemaquard and apricot trees are 50% smaller than those on seedling rootstocks. The peach and apricot trees on Pumiselect® rootstock are characterized by early bearing (2-3 year after planting) and about 50 % higher yield efficiency than those budded on Nemaquard. Another virtue of Pumiselect® rootstock is good cold endurance and resistance to *Plum pox virus* as well as good adaptation to heavy soil and drought. However, the trees on Pumiselect should not be grown on wet soil. Pumiselect® rootstock propagates readily from hardwood or softwood cuttings, stool beds or tissue culture (Okie, 2002).

The using of hardwood cuttings shortens the production of peach trees in the nursery, because, the rootstock can be budded in the year of planting of hardwood cuttings. The one – year – old peach trees were obtained in the second year after hardwood cuttings planting (Szewczuk and Gudarowska, 2005).

The aim of this study was to estimate suitability of hardwood cuttings to propagate Pumiselect® rootstock, depending on the diameter of cuttings and the use of the rooting stimulator

Materials and Methods

The experiment was conducted in 2002-2004 in the nurseries of the Fruit Experimental Station –Samotwór, near Wrocław (the south-western part of Poland). The Station belongs to the Department of Horticulture at the Agricultural University of Wrocław.

In autumn one-year-old hardwood shoots were cut in 40 cm long sections. The hardwood cuttings were calibrated into 2 groups according to the diameter > 5 mm and < 5 mm. In each group of hardwood cuttings, 50% of them were treated with the rooting stimulator 0,5% NAA. During the winter the hardwood cuttings were put in boxes with wet peat and were kept at a temperature of 3 ^{o}C.

In the spring, hardwood cuttings were planted in the nursery 20 cm deep at the spacing of 1.5 x 0.3 m. In the year of planting, the rootstocks were budded at the beginning of August by chip-budding method with buds of 'Redhaven' and 'Inka' cultivars.

In the autumn 6 rootstocks from each treatment were dug out and the quality of root system was estimated. The following data were recorded: the mass of roots with a diameter > 2mm and < 2 mm, the number of outgrowing roots, the mass of one-year and two-year-old rootstock stock, the number of shoots and their total length.

The experiment was established in a randomized block design with 6 replications. Each experimental plot consisted of 10 hardwood cuttings. The results of the study were subject to the analysis of variance. The significance of differences between means was tested by using Duncan's multiple range test at P = 0.05

Results and Discussion

The quality of the root system was very good in each year of the study. On the 20 cm long section of the hardwood cuttings, placed in the soil, the number of places with outgrowing roots amounted to 11.3-14.4. Hardwood cuttings with diameter > 5mm and rooting stimulator, had less number of places with outgrowing roots, than hardwood cuttings with diameter < 5mm rooted without stimulator (Table1).

Table 1. Quality of the root system of Pumiselect rootstock depending on the diameter of hardwood cuttings and a rooting stimulator, mean from 2002-2004

Diameter of hardwood cuttings	Mass of roots, g		Number of places with outgrowing roots
	roots with diameter >2 mm	roots with diameter < 2 mm	
< 5 mm	16.6 a*	5.9 a	14.4 b
< 5 mm + rooting stimulator	21.0 a	5.5 a	11.9 ab
> 5 mm	20.1 a	6.0 a	13.1 ab
> 5 mm + rooting stimulator	20.7 a	5.4 a	11.3 a

*Means followed by the same letters do not differ at P=0.05 according to Duncan's multiplate range t-test

Preliminary results showed that no factors (diameter of hardwood cuttings as well as the use of a rooting stimulator) had an influence on the mass of thick (> 2mm) and thin (< 2mm) roots (Table 1). In the years 2002-2004, hardwood cuttings of Pumiselect® produced more thick roots than small ones with diameter < 2 mm (Table 1).

On the 20 cm long section of the hardwood cuttings, placed in the soil, most of roots (57.5-69.5%) were grown at the base of rootstock 15-20 cm (the deepest part of rootstock). The use of the rooting stimulator increased the number of places with outgrowing roots in the deepest part of rootstock but the differences were not significant (Table 2). The diameter of hardwood cuttings as well as the use the rooting stimulator did not influence the prcentage of places with outgrowing roots in the middle part of rootstock stock (9.5-15.3%), (Table 2). However, in the case of thick hardwood cutting, the use of the rooting stimulator reduced the number of places with outgrowing roots in the highest part of rootstock (0-5 cm below the level of soil (Table 2).

Table 2. Percent of outgrowing roots at different length of rootstock, % (mean from 2002-2004)

Diameter of hardwood cuttings	Percent of places with outgrowing roots at different locations of the rootstock in the soil, %			
	0-5 cm	5-10 cm	10-15 cm	15-20 cm
< 5 mm	13.0 ab*	11.2 a	12.3 a	63.5 a
< 5 mm + rooting stimulator	11.2 ab	9.5 a	12.6 a	69.5 a
> 5 mm	14.8 b	12.5 a	15.3 a	57.5 a
> 5 mm + rooting stimulator	7.6 a	10.7 a	14.6 a	66.5 a

* Explanation- sees Table 1

The thicker hardwood cuttings promoted the grown top of the part of the rootstock (tab.3). The mass of rootstock (one and two-year–old) and its diameter was higher in case of rootstocks originating from hardwood cuttings with diameter > 5 mm. After one year of growing in the nursery the rootstock produced from thicker hardwood cuttings had longer shoots than those, obtained from hardwood cuttings with smaller diameter (< 5 mm) (Tab.3).

Table 3. Quality of top part of Pumiselect rootstock depending on the diameter of hardwood cuttings and on the rooting stimulator (mean from 2002-2004)

Treatment diameter of hardwood cuttings	Two-year -old part of rootstock		One-year-old part of rootstock		
	diameter of rootstock, mm	mass of rootstock stock, g	mass of rootstock stock, g	number of shoots	total shoots length, cm
< 5 mm	8.7 a*	30.6 a	17.6 a	5.1 a	160.5 ab
< 5 mm + rooting stimulator	9.2 a	32.5 a	21.3 ab	5.5 a	154.9 a
> 5 mm	10.5 b	38.4 b	33.4 c	5.6 a	196.7 c
> 5 mm + rooting stimulator	10.2 b	39.9 b	29.7 bc	5.3 a	192.4 bc

* Explanation- see Table 1

The obtained results correspond to the opinion of Okie (2002) concerning the possibility of propagating Pumiselect® rootstock by using hardwood cuttings. In case of Pumiselect® rootstock, propagated by hardwood cuttings, the quality of the root system did not depend on the diameter of cuttings and a rooting stimulator. However, the quality of hardwood cutting affected the top growth of the rootstock. According to Kiczorowski (1999), in case of apple rootstock, their growth in the first year in the nursery depends more on the type of rootstock than on their diameter.

Conclusions

The results obtained show that the use of hardwood cuttings is a suitable method for propagating Pumiselect® rootstock.

The diameter > 5 mm of hardwood cuttings, positively affected the top growth of the rootstock in the first year in the nursery.

The using of rooting stimulator did not improve the quality of the root system, and even reduced the number of outgrowing roots in the upper part of the hardwood cutting.

References

1. Kiczorowski P. (1999) Effect of rootstock on growth of ‘Szampion’ apple maiden trees in the nursery. Apple rootstocks for intensive orchards. Proceedings of the International Seminar. Warszawa, 55-56.
2. Kubiak K. (2001) Rynek brzoskwiń w Europie i w Polsce. Ogólnopolski Zjazd Producentów Brzoskwiń ISiK. Skierniewice, 5-20.
3. Okie W.R. (2002) Register of new fruit and nut varieties. List 41. Hort. Scence, Vol. 37 (2) 251-271
4. Radajewska B., Pisarska L. (1994) Brzoskwinie i nektaryny po zimie 1993/94 w Przybrodzie k. Poznania. Ogólnopolska Naukowa Konferencja Sadownicza 1994, 135-146
5. Rejman A., Ścibisz K., Czarnecki B. (2002) Szkółkarstwo roślin sadowniczych. PWRiL. Warszawa.
6. Szewczuk A. (2000) Nowoczesna uprawa brzoskwiń. Nowoczesna uprawa drzew pestkowych. Materiały XX Międzynarodowego Seminarium Sadowniczego. Limanowa, 69-78.
7. Szewczuk A., Gudarowska E. (2005) Kilka uwag o karłowej podkładce dla brzoskwini - Pumiselect®. Sad Nowoczesny 2, 20-22.
8. Treder W. (2001) Ochrona kwiatów brzoskwiń przed przymrozkami wiosennymi. Ogólnopolski. Zjazd Producentów Brzoskwiń ISiK. Skierniewice, 64-71.

GROWTH INTENSITY OF APPLE-TREES ON CLONAL ROOTSTOCKS BEFORE THE BEGINNING OF FRUIT BEARING
ĀBEĻU AUGŠANAS INTENSITĀTE UZ KLONA POTCELMIEM PIRMS RAŽOŠANAS SĀKUMA

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Kopsavilkums

Četru Baltijas valstu sadarbības projekta ietvaros no 2001. līdz 2004. gadam tika pētīta dažādu potcelmu piemērotība audzēšanai Igaunijas apstākļos. Divas šķirnes ´Belorusskoje Malinovoje' un ´Auksis' tika audzētas uz 11 puspundura un pundura klona potcelmiem. Potcelms M 9 tika izmantots kā kontrole. Koki tika stādīti Polli Dārzkopības Institūtā, Igaunijas dienvidrietumos 2001. gada pavasarī. Rakstā ir sniegts ieskats koku augšanas spara izvērtējuma rezultātos Igaunijas klimatiskajos apstākļos pirmajos četros gados dārzā. Pirmajos gados augiem spēcīgākais augums bija uz 'Buļboga', M 26 un B146 potcelmiem.

Abstract

In the years 2001-2004, the trial was carried out, within the collaborative project of four countries „Baltic Fruit Rootstock Studies", aimed at the evaluation of the suitability of different rootstocks for Estonian conditions. Performance of two apple cultivars, ´Belorusskoje Malinovoje' and ´Auksis´, was compared on 11 dwarfing or semi-dwarfing clonal rootstocks. M.9 served as control. The trees were planted at the Polli Horticultural Institute, southwest Estonia, in the spring 2001. Preliminary results, concerning initial tree vigour on different rootstocks and their resistance to Estonian climatic conditions during the first four years in the orchard, are given in this paper. In the first years after planting apple trees showed the strongest growth on the rootstocks 'Bulboga', M.26 and B146.

Key words: apple tree, clonal rootstocks, growth, vigour, Estonia

Introduction

Dwarfing and semi-dwarfing clonal rootstocks are lately widely used in apple growing worldwide, due to providing early and abundant bearing as well as high fruit quality. These intensive orchards are relatively less common in places with colder climates, like the Baltic region of Europe, where clonal rootstocks, originated from a warmer climate, show insufficient winter hardiness. In recent decades, many cold-resistant dwarfing and semi-dwarfing apple clonal rootstocks have been bred in Central-Russia, Poland, Germany and Baltic States. Their suitability for the Baltic region is still unclear, however. In 1998, a collaborative project, called „Baltic Fruit Rootstock Studies" was initiated at Pure Research Station, Latvia, aimed at the evaluation of various dwarfing or semi-dwarfing rootstocks for apple, pear, plum and cherry, simultaneously in Estonia, Latvia, Lithuania and in the Brest oblast' of Belorussia. Twelve types of dwarfing and semi-dwarfing apple rootstocks were included in the project (Bite *et al.*, 1999). The objective of the project was to assess the resistance of these rootstocks to the climate of the Baltic region as well as their effect on tree vigour, early bearing, yield and fruit quality.

Materials and Methods

The test material for all participants of the project was gathered at the Pure Experimental Station in the years 1998-2000. In Estonia, the apple rootstock trial was established in the southwester part of the country, at the Polli Horticultural Centre. In the Polli region the sum of temperatures over 5° C is 1800-1900° C, average minimal temperature varies in the range from -26 to -28° C. Average yearly precipitation ranges from 600 to-700 mm. The soil of the experimental plots was sandy loam of moderate fertility. The experiment area is situated on nearly flat land, with a west and west-north aspect, aside of valley. White mustard was grown as a pre-planting green manure on the experiment area. Farmyard manure, at the dose of 100 tons per hectare, as well as phosphorous-and potassium fertilisers (500 kg P_2O_5 and 500 kg K_2O per ha) were also applied before planting. Ammonium nitrate was then applied in the orchard, at the rate of 80 kg N per ha every year.

One- and two-year-old trees of ´Belorusskoje Malinovoje´ on 8 different apple rootstocks and of ´Auksis´ on 11 rootstocks, were planted in spring 2001.Out of the studied rootstocks, two (M.9 and M.26) were bred in East Malling, England; four (B9, B396, B146 and B491) in Michurinsk, Central Russia; two (P60 and P22) in Poland; one (Jork 9) in Germany; one (Pūre 1) in Latvia; and one (Bulboga) in Moldova. The control rootstock was M.9. Planting distance was 4 × 1.5 m. The trial was established in a randomised block design, in four replications, with 3 trees per plot, Trees were trained as spindle-bush. The soil beneath the fruit trees was treated with contact herbicides, and the grass between alleys was frequently mown. In every autumn the trunk diameter (at 30 cm above the ground), tree height and crown width were measured. Basing on these measurements, trunk cross-sectional area (TCSA) and canopy volume were calculated every year. The results were elaborated by the one-way analysis of variance. Significance of differences between treatment means was estimated using the Student´s test at the probability of error α=0.05.

Results and Discussion

Estonia is the one of the Baltic States, which is situated in the north and has a relatively severe climate. The winters of 2001-2004 were characteristic for this area – cold days alternated with periods of thaw. The coldest was the winter 2002/2003, when in January the air temperature dropped to -29º and -32º C. The studied trees were not greatly damaged, but close to the trial orchard, on a site, which was approximately 1 m lower, apple trees on M.9, planted in 2002, were destroyed. From this observation and from some earlier experiments (Palk, 1972; Veidenberg, 1981) it can be concluded that growing trees on M.9 is quite risky in Estonian conditions, due to poor winter hardiness of this rootstock. Tatarinov (1984) stated that “although roots of M.9 can survive only -10º C, it still is well-known dwarfing rootstock, which can grow well on any soil and trees grafted on M.9 bear fruit early and are productive with fruits of high quality”. M.9 certainly is one of the most popular apple clonal rootstocks in the southern areas of apple growing, but under Estonian, relatively, cold conditions it suits well only as reference for estimation of vigour of other dwarfing rootstocks.

Trunk diameter, tree height and canopy volume of the young 4-year-old apple trees grown on different rootstocks differed to a great extent. For both studied cultivars, the indices of tree size were significantly larger on M.26, Bulboga and B146, except for canopy volume of ´Auksis´ on M.26 or on B146 (Table 1).

Table 1. Trunk cross sectional area (TCSA), tree height and canopy volume of 4-year-old apple trees on different rootstocks

Rootstock	‘Belorusskoje Malinovoje’			‘Auksis’		
	TCSA cm^2	Height m	Canopy volume, m^3	TCSA cm^2	Height m	Canopy volume, m^3
M.9 (control)	4.7	1.65	0.45	4.7	1.68	0.77
M.26	9.1*	2.00*	1.46*	7.7*	1.88*	0.77
B.146	10.0*	2.05*	1.40*	9.9*	1.85*	0.87
Pūre 1	4.6	1.53	0.37	6.1	1.78	0.69
B.396	6.1	1.68	0.82	5.2	1.73	0.71
Jork 9	6.4	1.93*	1.07*	5.4	1.83*	0.71
P.60	5.0	1.63	0.70	4.5	1.63	0.70
Bulboga	9.3*	2.20*	1.52*	11.3*	2.18*	1.80*
B.9	-	-	-	4.7	1.58	0.41
B.491	-	-	-	5.7	1.83	0.73
P.22	-	-	-	4.2	1.68	0.47
$LSD_{..05}$	2.2	0.24	0.49	1.6	0.18	0.42

* Values significantly different from the control, M.9 rootstock

The tree height of both cultivars and also the canopy volume of ´Belorusskoe Malinovoe´ were relatively larger on Jork 9. The vigour of trees on other rootstocks did not significantly differ from that of trees on the control stock.

The annual increase of the trunk diameter describes the most objectively the rootstock effect on tree growth. It was noted that trunk diameter of trees increased in the year of planting only by 1-3 mm and was not affected by rootstock (Fig. 1).

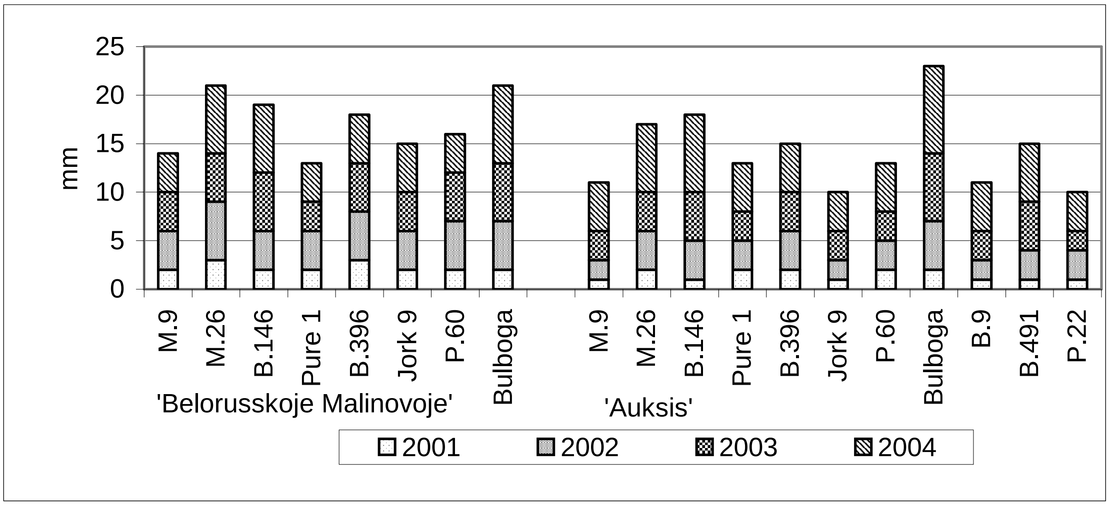

Figure 1. Increase of trunk diameter of apple trees in the years 2001-2004

In the next two years the trunk diameters increased by 2-6 mm per year and on the fourth year after planting it increased 4-9 mm. The effect of rootstock on trunk diameter started to show already from the second year after planting and was most noticeable in the fourth year. In 2004 the increase of the trunk diameter of the cultivar ´Belorusskoje Malinovoje´ on the rootstocks M.26, B146 and Bulboga was 3-4 mm larger and of cultivar ´Auksis´ 2-4 mm larger than on the M.9 rootstock. During the four-year period, the trunk diameter of ´Belorusskoje Malinovoje´ on the reference M.9 rootstock increased 14 mm, whereas on M.26, B146 and Bulboga 21, 19 and 21 mm, respectively. Trunk diameter of ´Auksis´ on M.9 increased 11 mm and on M.26, B146 and Bulboga 17, 18 and 23 mm. ´Belorusskoe Malinovoe´ and ´Auksis´ showed the overall trunk diameter increase 4 and 5 mm greater on B396 than on M.9. In case of the cultivar ´Auksis´, the increment of trunk diameter was 4 mm larger on B491 than on M.9. Trunk diameter increase of the studied cultivars on other rootstocks did not differ significantly from that on .the control rootstock.

So, the rootstocks M.26, B146 and Bulboga may be considered as semi-dwarfing, B396, B491 and Jork 9 intermediate between dwarfing and semi-dwarfing, while M9, Pūre 1, B9, P60 and P22 as dwarfing – in Estonian conditions. Depending on site, scion/rootstock combination or some other factors, opinions about the vigour of any clonal rootstock may be quite diverse. M.26, however, is regarded as semi-dwarfing also elsewere, including the Baltic region. According to Tatarinov (1984), during the first five years, it performs as semi-dwarfing only when grown on a fertile soil; on a less fertile soil it is dwarfing. Little information is available about performance of the rootstocks Bulboga and B146 in the Baltic region. In Latvia, Bulboga is considered as semi-dwarfing (Bite, 1999). In Poland, trees on B146 showed even weaker growth than trees on M.9 (Sadowski *et al.*, 1999). In Lithuania, P60 and B396 have been considered as semi-dwarfing (Kviklys, 2002) and in Latvia the Pūre 1, B9 and B396 have been classified as dwarfing rootstocks (Bite, 1999). Pūre 1 should be more vigorous than B9, but trees on these rootstocks have shown the same vigour (Lepsis, 1999; Lepsis and Bite, 2000). In Belorussia, B396 is considered as dwarfing or semi-dwarfing rootstock (Kapichnikova, 1999) and it is in line with our results.

Conclusions

The vigour of apple trees on different clonal rootstocks depends not only on rootstock, weather conditions or location, but also on the scion/rootstock combination. The complex analysis based on the results of the international project, carried out simultaneously in four Baltic countries, enables an objective evaluation of the rootstock effect on tree vigour to be made. Out of 11 apple rootstocks, studied during four years, M.26, B146 and Bulboga can be regarded as semi-dwarfing; M.9, Pūre 1, B9, P60 and P22 as dwarfing and B396, B491 and Jork 9 as intermediate between dwarfing and semi-dwarfing, in South Estonian conditions.

References

1. Bite A., Kviklis D., Haak E. and Lukut T. F. (1999) International project "Baltic fruit rootstock studies". In: Sadowski A. (ed.) Apple Rootstocks for Intensive Orchards. Proceedings of the International Seminar, Warsaw-Ursynów, Poland, 17–18.
2. Bite A. (1999) Short reports Pure-1: a new semi-dwarf-apple rootstock. In: Ikase, L. (ed.) Fruit Growing Today and Tomorrow. Proceedings of the International Scientific Conference dedicated to the 90th birthday of the fruit breeder A.Spolitis and the 100th birthday of the breeder V.Varna, Dobele, Latvia, 131. – 134.
3. Kapichnikova N.G. (1999) Effect of clonal rootstocks on apple tree performance during first five years after planting. In: Sadowski A. (ed.) Apple Rootstocks for Intensive Orchards. Proceedings of the International Seminar, Warsaw-Ursynów, Poland, 49–50.
4. Kviklys D. (2002) Apple rootstock research in Lithuania with aspect to fruit quality and tree productivity. Sodininkysté ir Daržininkysté / Horticulture and Vegetable Growing, Lietuvos Sodininkystés ir Daržininkystés Instituto ir Lietuvos Žemés Űkio Universiteto Mokslo Darbai / Scientific Works of the Lithuanian Institute of Horticulture and Lithuanian University of Agriculture 21 (3): 3–11.
5. Lepsis J. (1999) Evaluation of apple rootstocks B. 9 and Pure 1 in a modern orchard in Latvia. In: Sadowski A. (ed.) Apple Rootstocks for Intensive Orchards. Proceedings of the International Seminar, Warsaw-Ursynów, Poland, 69–70.
6. Lepsis J. and Bite A. (2000) The evaluation of apple rootstock Pure 1 in the orchard and mothertree plantation. In: Kaufmane E., Libek A. (eds.) Fruit production and fruit breeding, Proceedings of the International Conference, Tartu University Press, Estonia,15–19.
7. Palk J. (1972) Õunapuu vegetatiivsetest alustest. Sotsialistlik Põllumajandus, 23, 1090-1094 (In Estonian).
8. Sadowski A., Pająk T. and Półtorak W. (1999) Growth and early yield of 'Jonagold', 'Holiday' and 'Fiesta' apple trees on different rootstocks. Apple Rootstocks for Intensive Orchards. Proceedings of the International Seminar, Warsaw-Ursynów, Poland, 91–92.
9. Tatarinov A. N. (1984) Klonovye podvoi yabloni i grushi. Metodicheskie ukazaniya. Kolos, Moskva, 8–10.
10. Veidenberg A. (1981) Method of root refrigeration in soil-monoliths for studies on winter-hardiness of clonal rootstocks of apple. Proceeding of the Estonian Research Institute Agricultural and Land Improvement 46, 31–41 (in Russian).

TREE FRUIT NURSERY STOCK PRODUCTION IN HUNGARY
KOKAUGU STĀDĀMĀ MATERIĀLA AUGSTĀKO KATEGORIJU RAŽOŠANA UNGĀRIJĀ

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Kopsavilkums

1970-tajos gados Ungārijā izveidota vīrusbrīva stādāmā materiāla ražošanas, pārbaudes, izejas materiāla ražošanas un likumdošanas sistēma, kuru regulāri atjauno. Tiesiskais pamats veidots uz ES likumdošanas EPPO rekomendāciju bāzes. Pēdējos desmit gados vidējā augļukoku stādu produkcija sasniedz 5 milj. koku; viens miljons tika importēts – galvenokārt tās šķirnes, kuru stādus neaudzēja Ungārijā. 1990-to gadu sākumā kokaudzētavas tika privatizētas. Jaunizveidotās kokaudzētavas vēl joprojām cieš no nepietiekama pamatkapitāla un tehniskā nodrošinājuma. Būtisks ir moderno, aizsargāto šķirņu pavairošanas licenču trūkums. Starpvalstu sadarbība varētu būt nozīmīga modernizēšanas un šķirņu sortimenta paplašināšanas jomā.

Abstract

In the 1970-is a modern scheme of virus-free propagation system, indexing, nuclear stock was development and the official regulation developed in Hungary, has been regularly been updated. The recently accepted regulation considered both the EU legislations and the EPPO recommendations.
The Hungarian tree fruit nursery production in early 1990-is has endured a large recession caused by political and economical changes in East-Europe. This market situation caused a large recession in tree fruit production, touching bottom in 1992-1993. Since then fruit tree production has increased and nurseries were developing until 2003. The demand dramatically reduced again in 2004. The average nursery stock production over the last decade was around 5 million trees; one million were imported, mainly from those fashionable and protected cultivars not propagated by the Hungarian nurseries. In the early 1990-is the nurseries were privatized. The newly established private nurseries still suffer from the lack of capital, infrastructure (machinery, cold storage) and what is more, lack of propagation rights or licences of fashionable protected cultivars, which should represent a considerable part of nurseries' portfolio. International cooperation might be useful, both in technology transfer and in the modernization of cultivar assortment.

Key words: fruit tree nursery, tree production, land use, share of species, certification system, nuclear stock

Introduction

Over the last two decades the political and economical changes in Hungary brought to the tree fruit nursery industry many challenges. After the privatization numerous small nurseries were established. The dramatic changes in the market resulted in a large increase in demand and production. The open market increased the competition from abroad. In this small overview the development and today's situation of the Hungarian tree fruit nurseries will be presented.

Market situation

Over the last two decades the Hungarian tree fruit nursery industry two large recessions have been endured caused by political and economical changes in East-Europe. During the communist era the Hungarian fruit industry exported about one third of its products to the former Soviet Union and other East-European countries. After 1990 this market was lost caused by first of all the instability of payment. Due to this market loss the fruit production was reduced about 40-50%. In early 90-is new orchard planting was minimal. In addition to some uncertainties in land ownership reduced more the intentions to planting new orchards in the beginning of this decade. This market situation caused a large recession in tree fruit production in nurseries, touching bottom in 1992-1993.

Since then the fruit tree production was increasing, nurseries are developing until 2002. Since in 2004 Hungary joined the European Union the state support for planting of new orchard now is limited. This caused a dramatic fall again in fruit tree production (Fig. 1).

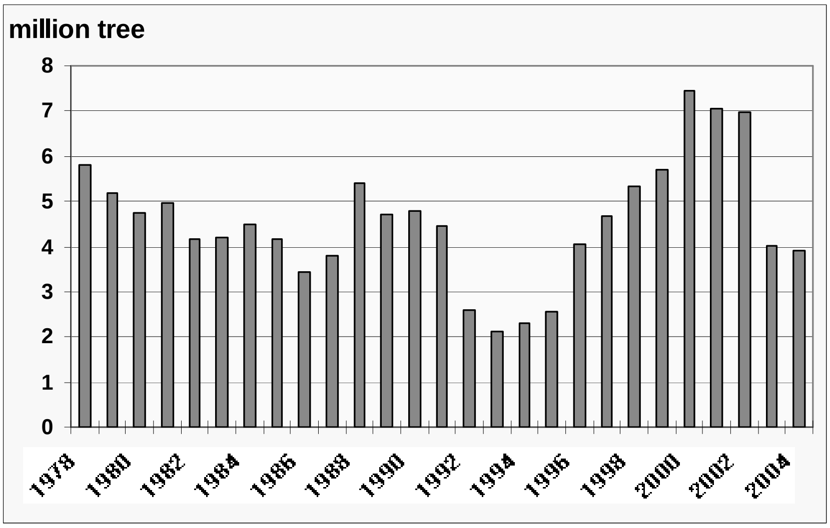

Figure 1. Fruit tree production in the Hungarian nurseries between 1978-2004 (by data of Bach *et al.*, 1998 and OMMI, 2005)

In average of the last ten years the domestic production of fruit trees reached 5.7 million pc (Bach *et al.*, 1998 and OMMI, 2005). In addition, around 1.2-1.4 million trees are imported from abroad, mainly fashionable cultivar-rootstock combinations. The demand of the home gardens represents the most firm market share for the domestic production can be estimated around 1.2-1.5 million trees/year. This demand, which represented the solid basis for the nursery production in the years of recession, is covered first of all by small local nurseries, with old, well known cultivars. The demand of industrial orchards fluctuated extremely over the last two decades (Fig. 1). The new orchards are high density planting, especially in pome fruits, thus the demand of trees is larger. The fruit growers are keenly interested in new cultivars and dwarfing rootstocks, which cannot be covered completely by national production. This large fluctuation caused by the demand of industrial orchards creates inconveniencies in covering demands on rootstocks, nuclear stock and of course tree production. In addition too, because of this fluctuation the renewal demand of those orchards planted between 2000 and 2002 will come around 2020, thus a new peak in production can be predicted.
The share of sold fruit tree species in the Hungarian nurseries can be seen in Fig. 2 (Bach *et al.*, 1998 and OMMI, 2005).

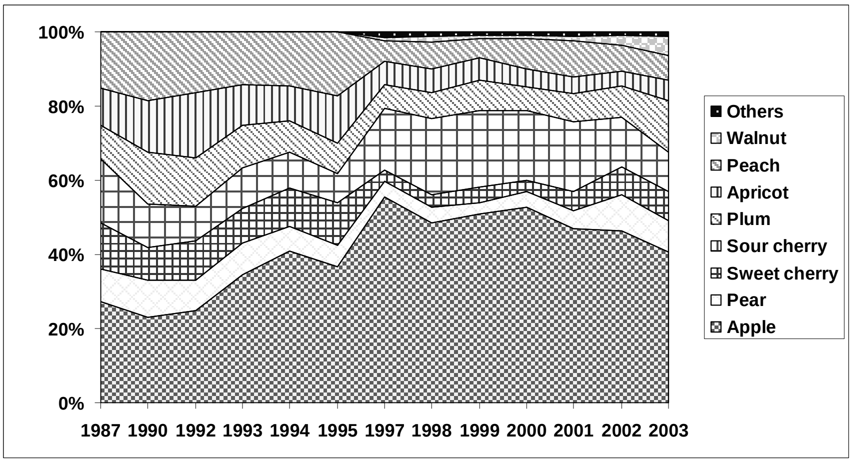

Figure 2. Share of fruit species in the Hungarian tree fruit production (by data of Bach *et al.*, 1998 and OMMI, 2005)

The leading species is apple, but the share of stone fruit species is considerable. The demand on tart cherries increased rapidly over the last decade because of the good market position of this species for export to Germany. In the last couple of years a decrease occurred. The share of sweet cherries, plums and prunes is slightly increasing; besides orchards for processing industry new intensive plantations occured and that is why increase is expected in this species. The production of apricot and peach trees is slightly decreasing while increasing share can be observed in walnut.

Fruit tree nurseries in Hungary

During the first years of 90-is, to the same time of large recession of fruit production, nurseries were privatized. This reorganization dramatical changed the structure of nurseries, their size and land use. Today the nursery industry is completely private owned. The number of nurseries producing fruit trees increased to 400 - 500 by the statistics (Bach *et al.*, 1998), fivefold in comparison to the number of nurseries before changes (Fig. 3).

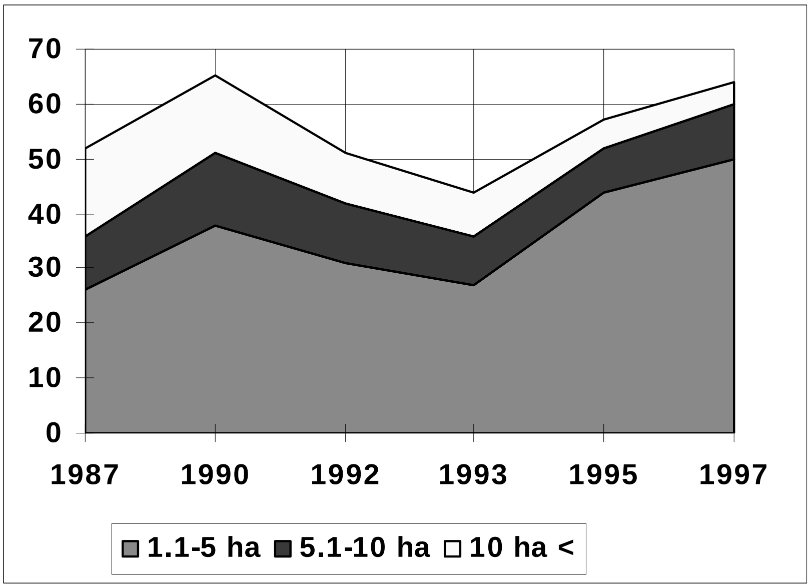

Figure 3. Changes in number of nurseries in upper three size groups during privatization (based on data of Bach *et al.*, 1998)

Thus the average size of nurseries rapidly reduced, now it is less than one hectare. This huge size reduction is partly virtual, caused by the large number of nurseries created to share the production between family members in order to reduce personal income tax payment. (There is no opportunity of family income tax payment in Hungary.) The number of regularly producing tree fruit nurseries can be estimated to 150, and the 70 % of total production comes from nurseries larger than 1 ha.
Both small (under 1 ha) and medium sized nurseries (from 1.1 to 5.0 ha) use 30 – 30 % of the total nursery land respectively, while larger than 5 ha nurseries uses 40% of total land (Fig. 4). This ratio in land use seems to be stable, which means that the situation of larger nurseries is stabilized.

Many large nurseries are originated from a former state farm or cooperative and now are companies. Facilities, equipment is inherited from the old large scale farms, small investment is made for the last decade. The largest inadequacy of means is the lack of propagation licences of new fashionable cultivars and consequently the lack of nuclear stock of those.

Certification and nuclear stock

In the 1970-is a modern scheme of virus-free propagation system, indexing, nuclear stock and the official regulation developed in Hungary, which had regularly been updated. Procedures of the up-to date transposition and integration of new requirements into the national scheme need continuous development. The recently accepted regulation on the national registration of plant varieties, as well the production, trade and certification of propagating materials considered both the EU legislations and the EPPO recommendations (Bach and Szőnyegi, 1996). Development and introduction of the advanced molecular diagnostic methods have been accomplished and their integration into the certification system is planned.

Hungary is a member state of the UPOV, thus the same variety protection can be requested and breeders are provided with the same rights as in other member states. The Hungarian propagation and certification system is harmonized with that of the European countries. Virus-free and virus indexed nuclear stock is planted in Érd, Research Institute of Fruit Growing and regularly inspected by the National Institute of Agricultural Quality Control (OMMI) and the National Phytosanitary Service. Nurseries are allowed to propagate only virus free or indexed trees from the nuclear stock. If there is not enough plant material available, standard propagation material is allowed (C.A.C.). Unfortunately new fashionable protected cultivars are not available in this system.

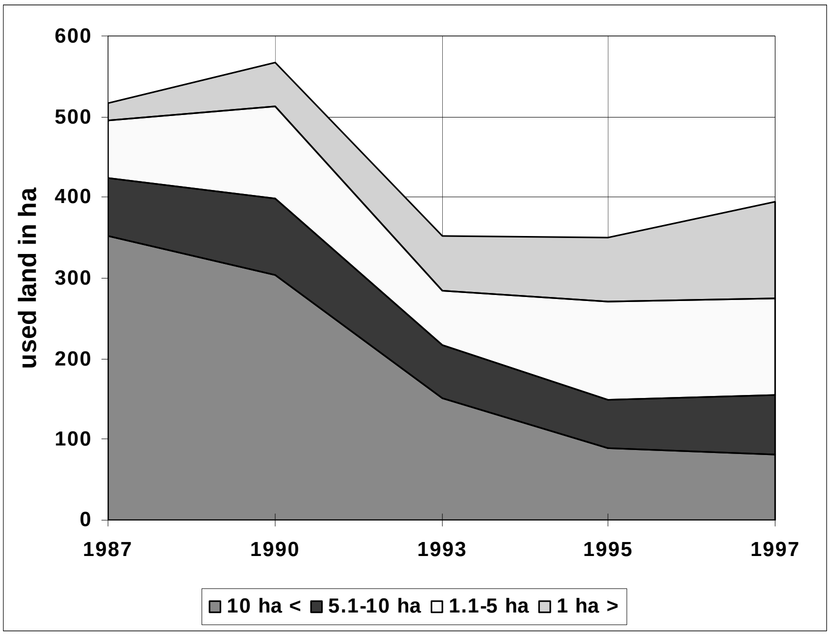

Figure 4. Changes in share of nursery land use between different sized nurseries during the privatisation (based on data Bach *et al.*, 1998)

R e s e a r c h

Research for tree fruit nursery industry is carried out at the Department of Pomology, Corvinus University of Budapest, and at Research Institute of Fruit Growing Érd, and Cegléd.

Research activity at the Department of Fruit Growing, Faculty of Horticulture, Budapest is focused more on principles in tree fruit propagation, like principles of seed orchard pollination, physiology of rootstock-scion relationship, but there are some topics of applied research. Good results are achieved in the field of plant bioregulator application in the tree raising. The benzyadenine (BA) and gibberellic acid (GA $_{4+7}$) treatment on apple, sweet cherry, and plums produced good feathering, using the Hungarian products Paturyl 10 WSC (BA) and Phyl-Gold (GA $_{4+7}$) (Hrotkó *et al.*, 1997, 1999; Magyar and Hrotkó, 2002). Advantages of chip budding versus T-budding have been proved in many trials on fruit and ornamental species, although the traditional T-budding is used in the majority of nurseries (Végvári and Hrotkó, 1999). Technology for hardwood cuttings of plum rootstocks has been developed (Szecskó *et al.*, 2003) and technology for leafy cuttings has been improved which allows the vegetative propagation of some newly selected rootstocks for stone fruits. Large series of rootstock testing and propagation trials are carried out in order to select appropriate rootstocks for the local ecological conditions which is chracterized by continental effects, drought, dry and cold winter and dry and hot summers (Hrotkó *et al.*, 1999; Hrotkó, 1999). Tree size reducing rootstocks are selected and created for sweet and tart cherries (’Bogdany’, ’Magyar’, ’Prob’), which is basic element of high density orchards, combined with appropriate training systems, like modified Brunner- spindle and slender spindle (Hrotkó, 2004).

Nursery research at the Research Institute of Fruit Growing in Érd is focused on vegetative propagated rootstocks for stone fruits (Bujdosó and Hrotkó 2005), and their propagation by leafy cuttings and micropropagation. Series of valuable rootstocks are selected or created at this institute, like ’Cadaman ® Avimag’, ’Peda’, ’Pema’ peach-almond hybrids or some plum rootstocks for apricot. Research Insitute of Fruit Growing in Cegléd focused their activity of seed tree selection (mazzard, mahaleb cherry, myrobalan, apricot, peach and pear), they planted a large virus free seed orchard with all stone fruit species and now deliver their seed products to many European countries.

Table 1. Recommendations for BA and GA $_{4+7}$ applications on nursery trees (Hrotkó *et al*, 1997, 1999; Magyar and Hrotkó, 2002)

Species, Cultivar	Paturyl 10 WSC, 10% BA)	Phyl-Gold, 1% GA $_{4+7}$
Apple		
Idared	0,3-0,4 % x3-4	4% x2-3
Jonagold	0,2 % x3-4	4% x2-3
Golden Delicious	0,2 % x3-4	4% x2-3
Mutsu	0,2 % x3-4	4% x2-3
Gloster	0,2 % x3-4	4% x2-3
Sweet cherry		
Germersdorfi óriás	0,5-0,6 % x4	4% x2-3
Van	0,3-0,4 % x3	4% x2-3
Linda	0,5-0,6 % x4	4% x2-3
Bigarreau Burlat	0,4-0,5% x4	4% x2-3
Plum		
Althann’s Gage	0,2-0,3 % x3-4	4% x2-3
Bluefre	0,2 % x3	4% x2-3
Stanley	0,2 % x3	4% x2-3

P r o s p e c t s

Despite of the recession tree fruit nursery industry in Hungary has promising prospects. After the shock caused by the joining to the EU the Hungarian fruit growing will represent a stable market, which will demand excellent tree quality for high-density orchards in increasing quantity. The same concerns the fruit industry of neighbour countries in East - Europe where the Hungarian nurserymen have good connections. Although Hungarian nurserymen are well educated specialist, there are some inadequacies, which delay them in covering the market demands. It can be traced back to lack of capital and modern mechanized technology, and partly to lack of propagation licences of new protected varieties. In filling these gaps international cooperation might be useful, especially joint ventures and cooperation in propagation of new fashionable cultivars, which may contribute to modernization of assortment. In return there are some valuable cultivars and rootstocks from the Hungarian selection and breeding which might be usable for the cooperation.

References

1. Bach I., Bakos J., Gőcze L., Munkácsi J., Nagy Áron., Paksi E., Szarka, Á., Vajdáné K.A. and Visnyei K. (1998) A gyümölcsfaiskolai ültetvényanyag-termesztés tíz éve. Published by OMMI, Budapest, 38.
2. Bujdosó G. and Hrotkó K. (2005) Ergebnisse der Leistungsprüfung der Kirschensorten auf wuchsreduzierenden Unterlagen in Ungarn. Erwerbsobstbau, 47, 46-53.
3. Hrotkó K. (1999) Evaluation of apple rootstocks in central Hungary. Proceedings of Int. Seminar on Apple rootstocks for intensive orchards, Warsaw-Ursynów, 33-35.
4. Hrotkó K. (2004) Cherry rootstock breeding at the department of Fruit Science, Budapest. Acta Hort. 658, 491-495.
5. Hrotkó K., Magyar L., Yao C. and Rónay Z. (1997) Effect of repeated BA (benzyladenine) application on feathering of ’Idared’ apple nursery trees. Horticult. Science, 29, (3-4), 46-51.
6. Hrotkó K. Magyar L. and Simon, G. (1999) Growth and yield of sweet cherry trees on different rootstocks. International Journal of Horticultural Science, 5 (3-4), 98-101.

7. Hrotkó K., Magyar L. and Őri B. (1999) Improved Feathering on One-year-old 'Ger-mersdorfi FL 45' Sweet Cherry Trees in the Nursery. Gartenbauwissenschaft, 64(2), 75-78.
8. Magyar L. and Hrotkó K. (2002) Effect of 6-Benzyladenine (BA) application on feathering of plum cultivars in nursery. Acta Horticulturae, 577, 345-350.
9. Bach I. and Szőnyegi S. (1996) The certification scheme of propagating material in Hungary. Published by OMMI, 91.
10. OMMI (2005) Statistics for 1997-2004.
11. Szecskó V., Csikós Á. and Hrotkó K. (2003) Propagation of plum rootstocks by hardwood cuttings. Int. Journal of Hort. Sci., 9(1) 23-28.
12. Végvári G. and Hrotkó K. (1999) Anatomical study of bud union formation in chip- and T-budded 'Jonagold' apple trees on MM 106 rootstock. Int. J. Hort. Sci., 5(1-2), 27-29.

SUPPRESSION OF SPININESS IN M.26 AND P.22 APPLE ROOTSTOCKS
DZELKŠŅAINĪBAS NOVĒRŠANA M.26 UN P.22 POTCELMIEM

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Kopsavilkums

Izmēģinājums tika veikts trīs eksperimentos, iekļaujot potcelmu aprausumu rindas un potcelmu stādījumus kokaudzētavā pirms acošanas M.26 un P.22 potcelmiem. Lai novērstu dzelkšņu attīstību tika lietoti dinitroanilīni (butralīns, butralīns + BFA un pendimetalīns). Sākotnējos pētījumos vēls butralīna vasaras miglojums 4000 mg l^{-1} koncentrācijā samazināja dzelkšņainību mātesaugiem dzelkšņainajiem *Malus robusta* 5 x M 9 hibrīdiem, bet izsauca paātrinātu lapu nobiršanu bez mizas bojājumiem. M.26 mātesaugiem divreizējs miglojums 1500 mg l^{-1} koncentrācijā neietekmēja dzelkšņainību. Potcelmu M.26 un P.22 stādījumā kokaudzētavā divreizējs miglojums ar jebkuru no minētajiem dinitroanilīniem 1000, 2000 vai 3000 mg l^{-1} koncentrācijā (butralīnam un BFA), un 1500, 2500 vai 3500 mg l^{-1} (pendimetalīnam) būtiski samazināja dzelkšņainību salīdzinājumā ar neapstrādātiem augiem. Divreizēja apstrāde ar rokām izrādījās efektīvāka par ķīmisko apstrādi.

Abstract

These studies were conducted in three separate experiments including rootstock production (mound layering) and rootstock liners (tree production prior to budding) using M.26 and/or P.22 plant materials. To counteract spininess in examined plants dinitroaniline compounds: butralin, butralin + fatty alcohols (BFA), and pendimethalin were applied. In a preliminary study late summer sprays of butralin at 4000 mg l^{-1} reduced spininess in stool beds of excessive spiny hybrids of *Malus robusta* 5 *x* M 9 but caused premature plant defoliation with no bark injury. In stool beds with M.26 plants two applications of 1500 mg l^{-1} did not affect spininess. In M.26 and P.22 rootstock liners two sprays of either butralin, BFA or pendimethalin at 1000, 2000 or 3000 mg l^{-1} (for butralin and BFA), or 1500, 2500 or 3500 mg l^{-1} (for pendimethalin) significantly reduced spininess as compared with intact plants but no differences in this respect among the chemicals and rates were found. Two manual operations were somewhat more efficient in spine removal than chemical treatments but no practical differences between them in the field were observed. There were no adverse residual effects of chemical treatments on nursery tree performance (Jacyna *et al*., 2002).

Key words: butralin, dinitroaniline, *Malus robusta* 5, mound layering, pendimethalin, rootstock liner

Introduction

Spininess is a characteristic of many *Malus* species, especially in the juvenile phase of plant growth (Cummins and Aldwinckle, 1983). However, in the stool bed a mother plant may produce both spiny (juvenile) and smooth (senile) shoots. Spines are particularly pronounced with *Malus robusta* 5 and its progeny, and some of the Malling series rootstocks as M.2, M.9 or M.26 (Cummins, 1992). Rootstocks from Polish series P are mostly free of spines except P.22 (Czynczyk, 1998). This undesirable feature makes both rootstock (layering) and nursery tree production (rootstock liners) costly and laborious. In both cases spines are removed by hand.

Various chemical compounds have been examined to inhibit spininess either in citrus rootstocks (Rouse, 1994) or ornamental trees (Quinlan and Pakenham, 1984), and suckers in tobacco plants (Mylonas and Panagos, 1978). Yet little research has been done in deciduous fruit rootstocks and nursery trees so far (Quinlan, 1978; Jacyna *et al.*, 2000). Most commonly used chemicals to counteract suckering (spininess) werse either dinitroaniline compounds such as butralin or butralin combined with fatty alcohols, or auxin derivative NAA-naphthaleneacetic acid (Quinlan, 1978; Keever and Foster, 1990; Jacyna *et al.*, 2000). The basic for either spine removal or desuckering is by using of no translocable chemicals. Studies on absorption and translocation of dinitroaniline compounds in many species indicated that little was translocated from the site of uptake to other parts of the plant treated (Ashton *et al.*, 1976). NAA may also act either as growth promotor or inhibitor depending on the organ treated and the concentration applied (Thimann *in* Westwood, 1978). NAA has shown to be very efficient in spine growth inhibition in apple rootstocks Geneva 30 (Jacyna *et al.*, 2000).

The objective of this research was to examine different dinitroaniline compounds to counteract spininess both in stool beds and in tree nursery liners. This report was divided into three parts comprising a preliminary study in apple rootstock stool beds (USA, 1995), apple rootstock stool beds (Poland, 1999), apple rootstock liners in nursery rows (Poland, 2000).

Materials and Methods

The chemicals used in reported experiments were as follows: Tamex ® - containing 360 g l^{-1} of butralin (N-sec-butyl-4-tetra-butyl-2,6-dinitroaniline) marked in this text as butralin; Tamex AG® - containing 75 g l^{-1} of butralin + 450 g l^{-1} of fatty alcohols (C_8 + C_{10}) marked here as BFA; Stomp 330 EC® - containing 75 g l^{-1} of pendimethalin {N-(1-etylpropyl)-3,4-dimetyl-2,6-dinitroaniline) marked in the text as pendimethalin. During these studies the following experiments were carried out:

E x p e r i m e n t 1 (p i l o t t r i a l - s t o o l b e d s) Mother plants of progeny of apple rootstocks *Malus robusta* 5 *x* Malling 9 (Cornell University Apple Rootstock Breeding Program) in stool beds established in 1990 were used. About 60-80 plants from each of the following excessive spiny hybrids: 74R5M9-760 (type 1), 74R5M9-707 (type 2), and 75R5M9BR-521 (type 3) were used. The plants were sprayed with butralin either at 1000, 2000, or 4000 mg l^{-1} to run off. The sprays were directed to the "future" budding zone located up to 30 cm from the soil line. The control plants remained intact (no spine removal). All measurements were made within the zone of chemical application and its equivalent in control plants. This trial was not replicated.

E x p e r i m e n t 2 (a p p l e r o o t s t o c k s - s t o o l b e d s) Mother plants of Malling 26 grown in stool beds established in 1994 were used. The plants were sprayed twice within the budding zone with butralin either at 500, 1000 or 1500 mg l^{-1}. First sprays started when the spines were approximately 2-3 cm long, and the second spray was applied 19 days later. After rootstock harvest the following measurements were performed: rootstock diameter at 5 cm above the soil line, cumulative length of roots assessed according to the scale (1 - $\leq$20, 2^0 - > 20 - $\leq$ 90, 3^0 - > 90 -$\leq$ 200, 4^0 - > 200 - $\leq$ 350, 5^0-> 350 cm), and total length of parent shoot. The experiment was set up as complete randomized block design with 10 replications of 3 plants each. The data was subjected to analysis of variance, and the means were separated with LSD test at $P<0.05$. Mutual relations between either rootstock diameter or length of parent shoot, and either cumulative length of spines or their total number were evaluated by Pearson's product moment correlation at $P<0.05$.

E x p e r i m e n t 3 (l i n e r s o f a p p l e r o o t s t o c k s M . 2 6 a n d P . 2 2) It was carried out using rootstocks M.26 and P.22 planted in nursery rows (0.8 x 0.3 m) in separate field sections. At the time of planting the liners were free of spines. The plants were treated twice in biweekly interval with one of the following chemicals: butralin either at 1000, 2000 or 3000, BFA at 1000, 2000 or 3000, and pendimethalin at 1500, 2500 or 3500 mg l^{-1}. The sprays were confined to the budding zone, and started when c.40% of plants showed spine length of 2-3 cm. The spines of control plants were removed by hand twice depending on spine regrowth. In order to examine the effect of tested compounds on spine suppression a group of 36 stocks of P.22 were left intact. Rootstock (liner) diameter was taken from each plant before and after the season. Upon completion of the growing season the following measurements were made within the zone of chemical application and its equivalent in control plants: number of spines and their length distribution, estimation of the treatment phytotoxicity by annual increment of rootstock cross-sectional area and weight of fresh mass of shoots grown out above the treated area, and visual observations of bud take. The data from M.26 and P.22 rootstocks were analyzed separately. Both experimental subsets were set up as complete randomized block design with 18 replications of 10 plants each. The significance of the results was tested by analysis of variance and means comparisons were made by Tukey's HSD at $P<0.05$ (Statgraphics Software).

Results and Discussion

The results obtained from our preliminary trial (experiment 1) showed that application of butralin, especially at 4000 mg l^{-1} may decrease the number of spines (Table 1; Figure 1, 2, 3).

Table 1. Effect of butralin on spine suppression in different progeny of *Malus robusta* 5 x Malling 9 apple rootstocks in stool bed, exp. 1 – pilot trial, 1995

Treatment, mg l^{-1}	Number of spines per plant		
	Hybrid		
	74R5M9-760	74R5M9-707	75R5M9BR-521
1000	5.0	5.8	4.4
2000	4.3	5.4	6.2
4000	2.9	3.3	3.9
0[y]	6.2	6.5	6.7

[y] untreated control (no spine removal)

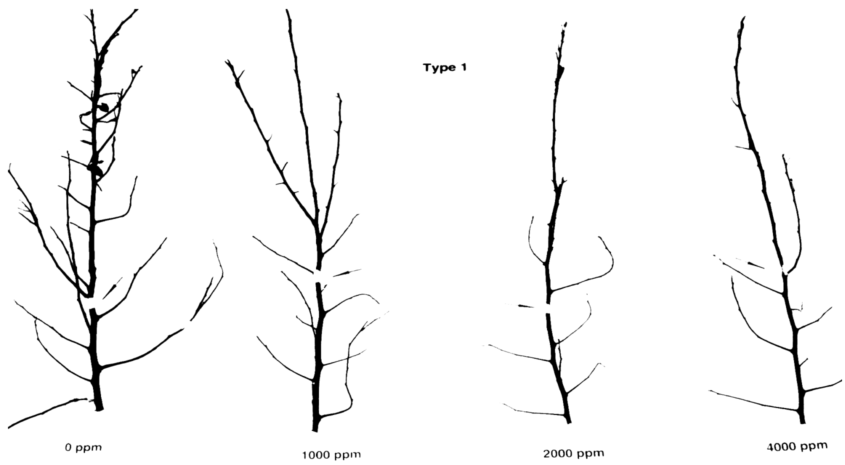

Figure 1. Effect of butralin application, in mg l^{-1} = ppm, on suppression of lateral growth in hybrid 74R5M9-760. Blank spaces on parent shoot indicate the upper limit of the compound application

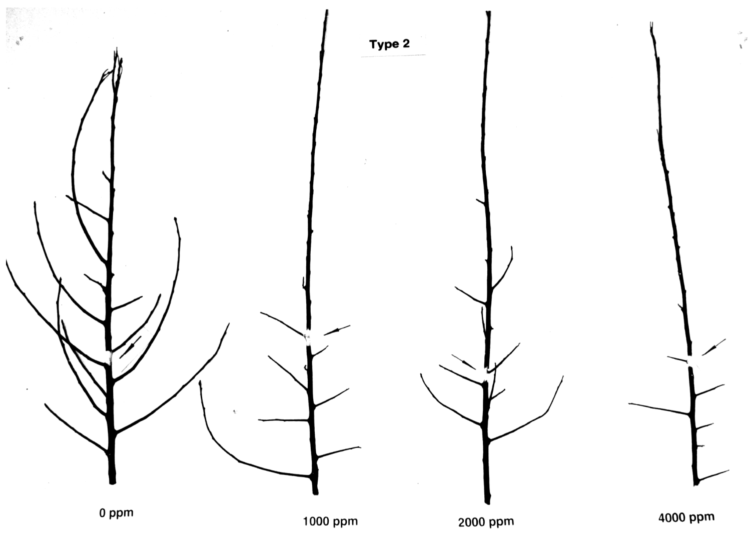

Figure 2. Effect of butralin application, in mg l^{-1} = ppm, on suppression of lateral growth in hybrid 74R5M9-707. Blank spaces on parent shoot indicate the upper limit of the compound application

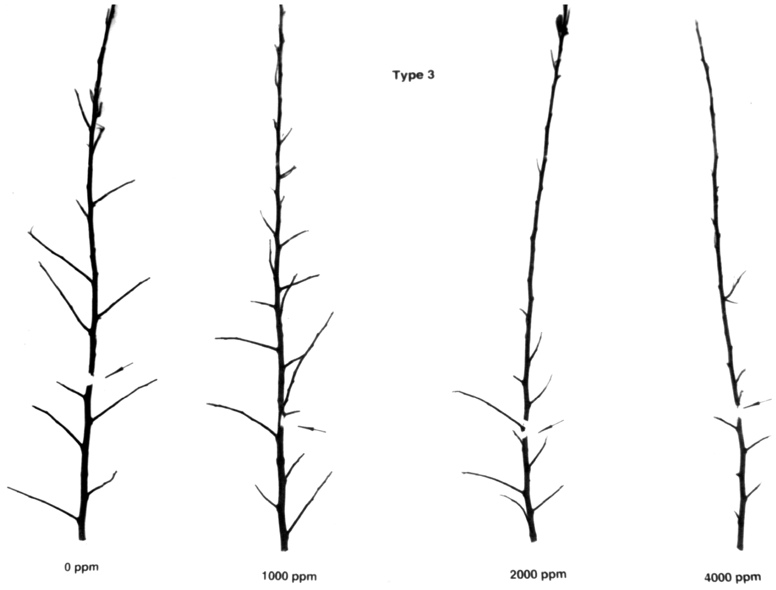

Figure 3. Effect of butralin application, sin mg l^{-1} = ppm, on suppression of lateral growth in hybrid 75R5M9BR-521. Blank spaces on parent shoot indicate the upper limit of the compound application

Malus robusta 5 and its progeny are known from excessive spininess (Cummins and Aldwinckle, 1983). Despite applying the chemical in late summer, the reduction in spine number was still satisfactory but the rate 4000 mg l^{-1} caused premature defoliation although no bark injury occurred. Visual observations showed that leaf injuries were confined to the zone of spraying with no translocation of these symptoms elsewhere.

Application of butralin in much lower concentrations than those used in experiment 1, did not bring about any suppression in spine growth of M.26 mother plants in stool beds (Table 2).

Table 2. Effect of butralin on spine suppression in M.26 apple rootstocks in stool bed (exp. 2, 1999)

Treatment, mg l^{-1}	Number of spines per plant			
	≤ 5 cm	> 5 - < 10 cm ^{z}	≥10 cm ^{z}	Total ^{z}
500 x 2	7. 0 b	1.0	0.5	8.5
1000 x 2	5.6 ab	1.0	0.5	7.1
1500 x 2	5.5 ab	1.0	0.6	7.1
0^{y}	4.9 a	1.4	0.8	7.1

Means followed by the same letter do not significantly differ at P<0.05
^{y} untreated control (no spine removal); ^{z} means are not significantly different

There were no significant differences in spine number between the control and chemically treated plants. Consequently to the results shown in Table 2, no differences in quality characteristics among the treatments were found (Table 3).

Table 3. Effect of butralin on some quality characteristics of M.26 apple rootstocks in stool bed (exp. 2, 1999)

Treatment, mg l^{-1}	Rootstock diameter, mm^{y}	Length of rootstock parent shoot, cm^{y}	Cumulative length of roots, in scale$^{y, z}$
500 x 2	8.1	88.0	2.9
1000 x 2	9.3	87.0	2.8
1500 x 2	8.8	87.3	3.1
0^{x}	9.3	92.4	2.9

^{x} untreated control (no spine removal); ^{y} means are not significantly different at P<0.05; ^{z} see Materials and Methods for scale explanation.

It would indicate that butralin applied in given rates (Table 2) did not influence the growth of treated plants as expressed by rootstock diameter, length of rootstock parent shoot and development of root system (Table 4). Comparison of adverse effects caused by single application of 4000 mg l^{-1} butralin (experiment 1) with no such effects with two sprays at 3000 mg l^{-1} butralin (experiment 3) demonstrates different responses of treated plants depending on plant type or chemical rate. Quinlan (1978) reported no detrimental effects in maiden apple trees treated with 3000 mg l^{-1} butralin but Knight (1979) found that the same rate of butralin caused serious defoliation of Quince rootstocks. The coefficients of correlation between basic rootstock quality parameters are given in Table 4. Spine growth expressed by cumulative length of spines and their number was positively correlated with the diameter and the length of rootstock parent shoot.

Table 4. Correlation coefficients for some quality characteristics of M.26 apple rootstocks in stool bed (exp. 2, 1999)

Correlation [y]	Coefficient of correlation, r	P-value
a x b	0.44	0.0000
a x c	0.20	0.0030
d x b	0.51	0.0000
d x c	0.35	0.0000

[y] a – rootstock diameter, b – cumulative length of spines, c – total number of spines, d – length of rootstock parent shoot

The results obtained from application of other dinitroaniline compounds, i.e BFA and pendimethalin indicated that both might be safely used in the desuckering of apple rootstocks (experiment 3). Both compounds performed in similar way as butralin in reducing spininess when compared with manual procedures (Table 5).

Table 5. Effect of dinitroaniline compounds on spine suppression in M.26 and P.22 apple rootstock liners (exp. 3, 2000)

Treatment, mg l^{-1}	Number of spines per plant						Total spine length/plant, cm[x]
	>0.5 - ≤1.0 cm		>2.0 –≤2.5 cm		>3.0 cm		
	M.26	P.22	M.26	P.22	M.26	P.22	
butralin:							
1000 x 2	4.3 b	0.1	0.7	0.1	0.8 ab	0.5 ab	6.1 a
2000 x 2	3.0 b	0.2	0.8	0.4	1.1 b	0.5 ab	6.2 a
3000 x 2	5.4 b	0.2	0.4	0.3	0.7 ab	0.4 ab	6.4 a
BFA:							
1000 x 2	4.4 b	0.1	0.3	0.4	1.0 b	0.7 b	6.5 a
2000 x 2	3.7 b	0.1	0.6	0.4	0.6 ab	0.1 ab	3.9 a
3000 x 2	3.5 b	0.1	0.3	0.4	0.5 ab	0.3 ab	5.7 a
pendimethalin:							
1500 x 2	4.2 b	0.0	0.5	0.3	1.4 b	0.2 ab	6.2 a
2500 x 2	4.9 b	0.1	0.5	0.3	0.8 ab	0.4 ab	4.8 a
3500 x 2	4.2 b	0.1	0.5	0.2	0.5 ab	0.7 b	5.9 a
hand removal [y]	0.0 a	0.0	0.0	0.0	0.0 a	0.0 a	
intact [z]							53.6 b
P - value	0.0000	NS	NS	NS	0.0031	0.0230	0.0000

Means followed by the same letter do not significantly differ at $P<0.05$, [y] spines were removed twice or more depending on their regrowth; [z] no spine removal; [x] additional experiment (36 replicates of single rootstock each); NS – not significant.

There were some significant differences in spine reduction between chemical treatments and manual deshooting depending on spine length. Double manual removal was more effective than chemical treatment. Short and long spines were more difficult to suppress than medium sized spines. This was particularly evident in Malling 26, and to the lesser extent in P.22 rootstocks (Table 5). However, from a nurseryman point of view, in most cases double chemical deshooting was as effective as double manual spine removal, being considerably less time consuming thus less expensive. Comparison of spine reduction effectiveness among the chemical treatments with exclusion of manual removal, showed no significant differences in relation to chemicals and rates applied (data not shown). Spine growth was significantly reduced by chemical treatments in comparison with intact plants (Table 5). Table 6 shows two characteristics of rootstock growth of which suppression may be considered as phythotoxicity indicators. Comparison of rootstock annual increment of cross-sectional area and the weight of fresh mass of shoots taken from untreated part of rootstock itself demonstrated no significant differences between chemically treated and untreated control plants (Table 6). The results of the follow-up research using previously treated rootstocks have shown no adverse residual effects on bud take and subsequent growth of budded trees as expressed by the number of feathers, diameter and height of trees in scab-immune apple cultivars 'Jonafree', 'Rajka' and 'Topaz' (Jacyna *et al.*, 2002).

Table 6. Performance of rootstock liners treated with dinitroaniline compounds for spine removal assessed at the end of season (exp. 3, 2000).

Treatment, mg a.i.l^{-1}	Annual increment of rootstock cross-sectional area, $(mm^2)^z$	Weight of fresh mass of shoots, g^z
butralin:		
1000 x 2	31.5	106.7
2000 x 2	37.2	125.0
3000 x 2	26.3	106.7
BFA:		
1000 x 2	38.1	108.3
2000 x 2	39.7	116.7
3000 x 2	44.3	95.0
pendimethalin:		
1500 x 2	35.0	115.8
2500 x 2	30.0	129.0
3500 x 2	34.7	106.7
hand removal ^{y}	25.6	111.0

All values are not significantly different at $P<0.05$, ^{y} double (triple) spine removal subject to spine regrowth, ^{z} mass of shoots taken from above the application zone.

Reduction in time and labor costs for spine removal is the main advantage of chemical deshooting of rootstocks. Results from this research, supported by the others (Rouse, 1994 and Jacyna *et al.*, 2000), indicate that chemical treatment may be competitive nursery technology with manual spine removal. It seems that in Poland the most suitable compound, which meets the criteria for chemical deshooting, would be pendimethalin (Stomp 330®), having official registration for fruit and vegetable production. However, more research is needed, especially in layering technology, to obtain precise protocols for various species.

References

1. Ashton, F.M., and Crafts, A.S. (1976) Mode of action-dinitroanilines. In 'Mode of action of herbicides, (Eds. F.M. Ashton, A.M. Crafts), New York, USA, 217-218.
2. Cummins, J.N. (1992) Geneva 65 (G.65) – a disease resistant, superdwarfing rootstock for apples. Compact Fruit Tree, 25, 620-65.
3. Cummins, J.N. and Aldwinckle, H.S. (1983) Breeding apple rootstocks. In 'Plant breeding review 1983', (ed. J.Janick), Westport, USA, 294-394.
4. Czynczyk, A. (1998) Podkladki zalecane do produkcji drzewek owocowych. In 'Szkolkarstwo sadownicze', Warszawa, Poland, 46-61.

5. Jacyna, T., Barnard, J., and Cummins, J.N. (2000) Chemical suppression of spininess in Geneva 30 apple rootstocks and its residual effects on nursery tree characteristics. Australian Journal of Experimental Agriculture, 40, 451-456.
6. Jacyna, T., Basak, A., and Sienkiewicz, P. (2002) Efektywność dolistnego stosowania forchlorfenuronu (CPPU) w rozgałęzianiu syleptycznym okulantów jabłoni odmian odpornych na parcha. Materiały Ogólnopolskiej Konferencji Sadowniczej, Skierniewice: 80.
7. Keever, G.J. and Foster, W.J. (1990) Control of basal sprouts regrowth on Crapmyrtle with NAA. Journal of Environmental Hortorticulture 8: 179-181.
8. Mylona V.A. and Panagos E.A. (1978) Effects of chemical agents on sucker control and on certain agronomic and chemical characteristics of burley tobacco. Tobacco International, 180, 167-170.
9. Quinlan J.D. (1978) The use of growth regulators for shaping young fruit trees. Acta Horticulturae, 80, 39-48.
10. Quinlan J.D. and Pakenham E.M. (1984) Effects of manual and chemical control of lateral shoots on the growth of young ornamental trees. Journal of Horticultural Science, 59, 45-50.
11. Rouse E.R. (1994) Controlling citrus rootstock sprouting in the nursery using Tre-Hold. Proceedings of Florida Horticultural Society, 107, 18-20.
12. Westwood M.N. (1978) Growth regulators. In 'Temperate zone pomology', (Ed. M.N.Westwood), San Franciscos, California, USA, 283-298.

THE EFFECT OF DIFFERENT PROPAGATION METHODS ON THE YIELD AND FRUIT MASS OF PLUMS
DAŽĀDU PAVAIROŠANAS VEIDU IETEKME UZ PLŪMJU RAŽU UN AUGĻU MASU

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Kopsavilkums

Deviņas plūmju šķirnes (4 Rietumeiropas un 5 vietējās) tika pavairotas *in vitro* un acotas uz *Prunus cerasifera* Ehrh. sēklaudžu potcelma. Izmēģinājums tika ierīkots Polli dārzkopības institūtā 1998. gadā. No 2001. līdz 2004. gadam veica uzskaiti. 2001. gadā netika konstatētas būtiskas atšķirības starp pavairošanas veidiem visām šķirnēm. 2002. gadā koki, kuri bija pavairoti *in vitro* deva augstāku ražu. Taču visā uzskaites periodā būtiskas atšķirības starp pavairošanas veidu netika konstatētas, nelielas atšķirības ražībā novērotas starp šķirnēm. Augstākās ražas ievāktas no šķirnēm 'Vilnor' un 'Märjamaa'. Arī pēc augļu masas netika novērotas būtiskas atšķirības.

Abstract

Nine plum cultivars (4 of West European origin and 5 local cultivars) were propagated *in vitro* or budded on the vigorous *Prunus cerasifera* Ehrh. seedling rootstock. The scion plant material for propagation *in vitro* and for budding was taken from the same, single mother trees. The experiment was established at the Polli Horticultural Institute in spring 1998. In the years 2001-2004 yield and mean fruit mass were compared. In 2001 no significant differences due to the propagation methods were found in the average values of all cultivars. In 2002 *in vitro* propagated trees appeared more productive than trees grown on *P. cerasifera*. In contrast, in 2003 and 2004 trees propagated *in vitro* gave a higher yield. In the cumulative yield (average of all studied cultivars) no significant differences between the propagation methods were noted. The cumulative yield of 'Polli Munaploom' was higher from *in vitro* propagated trees, whereas 'Queen Victoria' and 'Märjamaa' were more productive when grown on the vigorous, seedling rootstock. 'Wilhelmine Späth', 'Emma Leppermann' and 'Liivi Kollane Munaploom' gave insufficient yield. A higher yield was obtained from cultivars 'Vilnor' and 'Märjamaa'. No significant differences in mean fruit mass due to the propagation methods were found, considering the average values of all cultivars.

Key words: plum, *in vitro*, budded, seedling rootstock, yield, fruit mass

Introduction

Under Estonian conditions, plums have been propagated mostly by means of budding on seedlings of the vigorous cherry plum (*Prunus cerasifera* Ehrh.) so far. Nowadays, in the case of propagation of virus free fruit trees, the tissue culture method has been more frequently used. As the micro-propagated fruit trees are own-rooted, rootstock is not needed for them any more. Rootstock may influence productivity of a scion cultivar, fruit size and other quantitative traits. It is, however, hard to predict how the fruit trees may behave on any rootstock in the orchard. The trees achieve their final size several years after planting. The objective of the present research was to assess the performance of *in vitro* propagated trees of different plum cultivars in the orchard, in comparison with the conventionally propagated trees, grown on rootstocks.

Materials and methods

The trial was established in 1998 at Polli Horticultural Institute, South Western Estonia. The scion propagation material for budding and for *in vitro* propagation was taken from the same, single mother trees. Seedlings of the vigorous cherry plum (*Prunus cerasifera* Ehrh.) were used as rootstocks. The own-rooted plant material was propagated in the laboratory and then grown in a greenhouse and nursery. The trial included 4 West European cultivars: 'Emma Leppermann', 'Duke of Edinburgh', 'Wilhelmine Späth' and 'Queen Victoria' and 5 cultivars of local importance: 'Vilnor', 'Polli Munaploom', 'Noarootsi Punane', 'Märjamaa' and 'Liivi Kollane Munaploom'. The trial was established in 4 replications, with three trees per replication. The planting pattern was 3×5 m. Permanent sward, frequently mown, was maintained in alleyways. Soil along the rows was kept weed-free by herbicides. In the years 2001-2004 the yield per tree and mass of 100 fruits were recorded.

Weather conditions differed greatly during the trial period. The greatest annual rainfall occurred in 2001 – 906 mm, whereas the average annual rainfall for Estonia has been 500-700 mm. In the years 1998, 2003 and 2004 the amount of precipitation was slightly above 700mm, whereas the years 2000 and 2002 were poor in precipitation, 595 and 652 mm respectively. The most unfavourable year for plant growth was 2002 when only 47% of the average annual precipitation occurred (305 mm).

In 2000 a frost of -5º C occurred in the bloom time of plums. The winter of 2001/2002 was unfavourable for plum trees, as in December the temperature dropped to -27º C. The winter 2002/2003 was even more unfavourable, as the temperature stayed below -30º C for five days. On January 11 the minimal temperature reached -32º C at 2 m above the ground and -37.6º C at snow level. Winter frost damage was apparently aggravated by the fact that trees entered winter weakened by the summer drought of 2002. In May of 2004 the frost down to -4.5º C occurred again at full bloom time of the plum trees. Night frosts repeated until the end of May.

Two-factorial analysis of variance was used for the mathematical analysis of the trial data. For assessment of significance of differences between treatments the least significant difference (LSD) was calculated at the 95% probability. The asterisks (*) at the respective values in tables indicate significant differences.

Results and Discussion

In 2000 all cultivars, except for 'Emma Leppermann', flowered abundantly, however, a night frost destroyed all flowers. The first crop was harvested in 2001. Yield per tree varied from 0.1 to 7.4 kg (Table 1). Considering yield per tree as the average of all cultivars, the effect of the propagation method was insignificant. *In vitro* propagated trees were more productive in the case of the cultivars 'Vilnor' and 'Noarootsi Punane', whereas 'Märjamaa' and 'Queen Victoria' gave higher yields from the budded trees. In 2002 the highest yields were obtained in this trial: 3.7-19.3 kg per tree, depending on the cultivar. On the average of all cultivars, more productive were budded trees. Considering particular cultivars, 'Märjamaa' and 'Queen Victoria' were more productive as budded in that year. In the case of the cultivar 'Polli Munaploom' the opposite trend was noted, as *in vitro* propagated trees were more productive than budded ones. In 2003, after a severe frost damage, the yield dropped to 0.7-12.6 kg. The average yield (of all cultivars) was higher from *in vitro* propagated trees. Considering particular cultivars, the method of propagation affected only 'Duke of Edinburgh'; significantly higher yield was obtained from *in vitro* propagated trees. In 2004 a night frost during the flowering season damaged most of the flowers. The yield of cultivars 'Polli Munaploom' and 'Queen Victoria' and the average yield of all cultivars were higher in the case of *in vitro* propagated trees.

Table 1. Yield of plum cultivars depending on the propagation method, kg per tree

Cultivar	2001		2002		2003		2004	
	B	TC	B	TC	B	TC	B	TC
Vilnor	4.4	6.4*	14.9	14.0	3.0	3.2	15.6	15.3
Wilhelmine Späth	1.0	0.5	7.0	4.4	0.9	0.8	2.7	3.6
Noarootsi Punane	1.8	4.7*	13.0	13.4	0.9	0.8	2.9	2.9
Polli Munaploom	0.6	2.0	12.3	17.2*	1.5	1.3	4.0	8.1*
Märjamaa	4.3	1.0*	19.3	12.0*	10.6	12.6	6.9	4.6
Liivi Kollane Munaploom	0.5	0.8	9.2	9.1	0.7	2.8	1.1	1.8
Duke of Edinburgh	0.5	0.2	14.1	9.7	4.4	11.7*	4.7	6.0
Queen Victoria	7.4	0.8*	17.7	4.4*	5.6	7.3	3.6	9.1*
Emma Leppermann	0.1	0.1	3.7	3.9	2.8	4.3	2.8	4.1
Average of nine cultivars	2.3	1.9	12.4	9.9*	3.4	5.0*	4.9	6.2*
$LSD_{.05\ cultivar}$	1.6		4.5		4.0		3.3	
$LSD_{.05\ propagation\ method}$	0.6		1.5		1.3		1.1	

B – budded on seedling rootstock; TC – raised from tissue culture; * – significantly differant values for TC trees

No effect of the propagation method upon the average cumulative yield was noted (Table 2). Considering particular cultivars, 'Queen Victoria' and 'Märjamaa' produced higher yields in the case of *in vitro* propagated trees. Basing on the four-year trial results, 'Vilnor' and 'Märjamaa' proved to be the most productive cultivars. 'Emma Leppermann', 'Wilhelmine Späth' and 'Liivi Kollane Munaploom' gave rather moderate yields.

Table 2. Cumulative yield, kg per tree (for the years 2001-2004)

Cultivar	B	*TC*	Average for both propagation methods
Vilnor	37.8	*38.9*	38.4d
Wilhelmine Späth	11.6	*9.4*	10.5a
Noarootsi Punane	18.6	*21.8*	20.2b
Polli Munaploom	18.4	*28.6*	23.5bc
Märjamaa	41.1	*30.2*	35.6d
Liivi Kollane Munaploom	11.6	*14.5*	13.1a
Duke of Edinburgh	23.7	*27.6*	25.6bc
Queen Victoria	34.3	*21.7*	28.0c
Emma Leppermann	9.4	*12.3*	10.9a
Average of nine cultivars	22.9	*22.8*	
$LSD_{.05\ cultivar}$	*9,2*		
$LSD_{.05\ propagation\ method}$	*3.1*		
$LSD_{.05\ cultivar\ average}$			6.5

For explanations – see Table 1

Mean values of all cultivars did not show any significant effect of the propagation method on the mean fruit mass (Table 3). In 2001 fruits of budded trees of 'Queen Victoria' were larger than fruits of *in vitro* propagated trees. In the case of the cultivar 'Polli Munaploom' the opposite occurred. In 2002 fruits of *in vitro* propagated trees were larger than the fruits of budded trees of 'Duke of Edinburgh' and 'Queen Victoria'. In 2004 this was true for the cultivar 'Emma Leppermann'.

Table 3. Mean fruit mass of different plum cultivars depending on the propagation method, g

Cultivar	2001		2002		2003		2004	
	B	TC	B	TC	B	TC	B	TC
Vilnor	24	22	24	23	25	28	24	23
Wilhelmine Späth	21	20	23	22	19	19	19	20
Noarootsi Punane	20	19	21	19	17	16	21	21
Polli Munaploom	46	48*	42	39	45	46	45	47
Märjamaa	25	24	27	26	28	26	27	26
Liivi Kollane Munaploom	33	32	27	27	27	29	31	28
Duke of Edinburgh	28	30	35	38*	28	29	34	32
Queen Victoria	36	33*	42	45*	36	36	40	38
Emma Leppermann	29	28	38	37	32	36*	32	36*
Average of nine cultivars	29	29	31	31	29	29	30	30
$LSD_{.05\ cultivar}$	2.4		2.5		3.5		3.5	
$LSD_{.05\ propagation\ method}$	0.8		0.8		1.2		1.2	

*For explanations – see Table 1

The present trial was established in the northernmost region of fruit tree growing with medium soil fertility. The productivity of trees was affected by low temperature damage to shoots and branches in the winters. Of 2001/2002 and 2002/2003 and at so night frosts in bloom time caused serious damage to glowers and young leaves in spring 2000 and 2004. No differences in the degree of frost damage due to propagation methods were observed, however.

Despite the cost of equipment, necessary for raising micro-propagated plants, the method is being used more and more for the quick propagation of trees. As a result own-rooted, virus-free material is obtained. Certain cultivars are more sensitive to micro-propagation conditions (Sansavini *et al.*, 1990). Experimentally different cultivars should be tested whether micro-propagation is commercially justified. It has been found out that *in vitro* propagated plum trees start flowering and cropping later (Zimmermann, 1988 and Cobianchi *et al.*, 1992). A typical trait is that these trees have a low percentage of flowering trees and a low mean number of flowers per tree during the first year of flowering (Popov and Prodanova, 2002). Our trial proved that propagation method did not influence the initial bearing of plum trees. Depending on specific features of particular cultivars, they may be more or less suited to growing as own-rooted trees or trees conventionally budded on rootstocks. This fact has been reported from trial results obtained elsewhere with different cultivars. Lech *et al.* (1998), studying two plum cultivars 'Sweet Common Prune' and 'Stanley', found that yield and fruit mass of *in vitro* propagated 'Stanley' trees was similar to the yield and fruit size of trees budded on cherry plum (*Prunus cerasifera* Ehrh.); on the other hand, trees of 'Sweet Common Prune' were by 50% smaller and started cropping one year later than budded trees. Faber *et al.* (2002) compared *in vitro* propagated plum cultivars and those grafted on 'Wangenheim' seedling rootstock it was found out that during the first two years of cropping more productive were trees on rootstocks. While during the third and fourth year – *in vitro* propagated trees; the cumulative yield of four years was similar. A similar tendency was observed in our trial as well.

Fruit trees start bearing fruit several years after planting in the orchard. The question whether micro-propagated trees are equal or even surpass budded trees in productivity should be tested separately for any cultivar. The initial differences may be levelled with time. The most important factors determining productivity of plum trees are apparently climatic conditions and the growing site.

References

1. Cobianchi D., Liverani A., Faedi W., Salvador F., Insero O., Pennone F., Rivalta L., Maltoni M.L. and Minquzzi A. (1992) Valutazione agronomica di materiale vivaistico micropropagato. Informatore Agrio, 48, 43-47.
2. Faber T., Lech W., Malodobry M. and Dziedzic E. (2002) Assessment of growth and cropping of the plum trees growing on Wangenheim prune rootstock and originated in vitro. Acta Horticulturae, 577, 51-56.
3. Lech W., Malodobry M., Dziedzic E. and Faber T. (1998) Assessment of growth and cropping of the plum tree originated from in vitro. Acta Horticulturae, 478, 187-192.
4. Popov S.(1993) Behaviour of the micropropagated Stanley plum cultivar in the plantation. Biotechnology and Biotechnological Equipment, 7 (1), 21-23.
5. Popov S. (2002) Behaviour of micropropagated own-rooted trees of plum cv. Stanley in the orchard. 1. Growth behaviour. Acta Horticulturae, 577, 363-374.
6. Popov S. and Prodanova M. (2002) Behaviour of Micropropagated Own-rooted Trees of Plum cv. Stanley in the Orchard. 2. Reproductive Behaviour. Acta Horticulturae, 577, 375-378.
7. Sansavini S., Buscaroli C., Martelli S. and Palara U. (1990) Observations on the behaviour of micropropagated and grafted plums. Rivista di Frutticoltura e di Ortofloricultura, 52 (6), 35-38.
8. Zimmermann R.H. (1988) Micropropagation of woody plants: post tissue culture aspects. Acta Horticulturae, 227, 489-499.

SCIENTIFIC AND LEGAL INSURING OF FRUIT NURSERIES IN RUSSIA
AUGĻUKOKU KOKAUDZĒTAVU ZINĀTNISKAIS UN JURIDISKAIS NODROŠINĀJUMS KRIEVIJĀ

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Kopsavilkums

Viskrievijas Dārzkopības selekcijas un stādu audzēšanas institūtā tiek ieviestas ekonomiskas, uz jaunākajiem zinātnes sasniegumiem balstītas augļukoku stādāmā materiāla audzēšanas metodes. Tās ir balstītas uz zemstikla platību, īpaši patentētu metožu, ekoloģiski drošu un fizioloģiski aktīvu vielu izmantošanu. Diemžēl potcelmu selekcija un izmēģinājumi šajā jomā ir nepietiekami, bet Rietumeiropas potcelmu klonus var izmantot tikai dažos Krievijas reģionos. Tādi sēklaudžu potcelmi kā `Anis`, kurš ir izveidots Rosošanskas izmēģinājumu stacijā, un dažas bumbieru šķirnes ir piemēroti Krievijas vidienes klimatiskajiem apstākļiem atveseļota stādāmā materiāla audzēšanai. Arī Viskrievijas Dārzkopības selekcijas un stādu audzēšanas institūtā izveidoti daži augstražīgi un ziemcietīgi bumbieru potcelmi (`Valesa` u.c.)

Abstract

The All-Russian Institute of Breeding Technologies in Horticulture and Gardening Nursery which has guided the world scientific achievements and advanced experience of intensive horticulture's countries has elaborated energy-efficient and resource-saving technologies of horticultural plant material growing. It is based on glass-house culture, special patent methods and ecologically clean, physiologically active substances of new generation. Unfortunately today rootstock selection and trials are insufficient for the Russia scientific level, and rootstocks grown in West Europe can be used only in a few regions of vast the Russian territory. No doubt that seedling rootstocks such as 'Anis' seedling and some pear varieties selected at Rossoshan experimental station in middle-cold climatic conditions of Middle Russia, will retain their importance and will be applied in sanitated plant material production of seed cultures. The All-Russian Institute of Breeding Technologies in Horticulture winter-hardy rich crop pear cultivars as 'Velesa' and other have been selected.

Key words: fruit nursery, insuring, patent methods

Introduction

The All-Russian Institute of Breeding Technologies in Horticulture and Gardening Nursery has guided the world is scientific achievements and advanced experience of intensive horticulture's countries has elaborated energy-efficient and resource-saving technologies of horticultural plant material growing. It is based on glasshouse culture, special patent methods and ecologically clean, physiologically active substances of new generation (adaptogens, nano-materials).

All modern elaborations of Fruit Nursery Department of The Institute of Breeding Technologies are based on scientific system of fruit, nursery, elaborated in cooperation with scientific institutes of Russia, Belorussia and Latvia.

As by 2020 it is planned the areas of gardens and berry plantations to be increased by 62,6%, the Breeding Nursery staff has set the task to obtain the highly productive cultivarss of fruit and berry plant species with digenic and polygenic stability against negative effects that moreover offers dessert fruit with high biological activity.

We are remainded of the colloquialism of the Russian scientist and gardener I.V. Michurin "the stock forms the basis of fruit tree". That is why investigations in the sphere of fruit species rootstock quality improvement must be the priority in fruit nursery.

According to our estimations for medical standarts' insurance, fruit consumption by the year 2020 will increase on such scale that Russia must produce not 6 million, but 120 million plants for intensive gardening.

That means that by this period it is necessary to grow more than 200 million rootstocks every year.

In contrast to West Europe (Poland, Germany, England) where 50% of apple-tree plantations will soon be occupied by the stock M 9 (A. Makosh, 1998), Russia situated in cold, moderate and even sub-arctic climate, needs special stocks to raise on the basis of transgressive adaptive selection.

Unfortunately today rootstock selection and trials are insufficient for the Russia scientific level, and rootstocks grown in West Europe can be used only in a few regions of the vast Russian territory.

No doubt that seedling rootstocks such as ‘Anis’ seedling and some pear varieties selected at Rossoshan experimental station in middle-cold climatic conditions of Middle Russia, will retain threir importance and will be applied in sanitated plant material production of seed cultures.

New generation element-organical substances application at mother plantations for grafts processing permits not only manage rhizogenesis but also affect stock growth.

More and more attention of horticulturists is attracted by pear cultivars. They not only obtain perfect fruit medical and diet qualities but owing to less inclination for periodical fruit-bearing and flower damage annualy produce high crops.

In All-Russian Institute of Breeding Technologies in Horticulture winter-hardy rich crop pear cultivars have been selected (‘Velesa’ and other). At the Kokinsky base station of the All-Russian Institute of Breeding Technologies in Horticulture winter-hardy varietes of pear with fruit weight more than 250 g, kept up to February, were selected basing on I.V. Kazakov and A.A. Vysotsky investigations data.

At the All-Russian Institute of Fruit Plants and Selection by I.V. Michurin pear varietes with complex stability against a number of diseases have been selected by S.P. Yakovlev with colleagues; and afterwards it was improved on the basis of *Pyrus ussuriensis* and its derivations. Such cultivars as ‘In memory of Iakovlev’, ‘Autumn dream’ and several other are valuable for of winter consumption and bacterial fireblight stability - the most dangerous and harmful pear disease.

The best pear cultivars have been worked out at Selection Institute (Orel) and at Timiryazev Agricultural Academy also.

New pear plantations laying out often fail not only for economical reasons, but for the lack of rootstock. The problem of high quality pear seedling rootstock growing is a type of root.

The magnetic-discharge rootstock processing (A.A. Borisova, T.V. Beshnov, A.A. Fachrutdinov, 2005.) increases biometrical data of the overground part and changes the architectonic characteristics of root the system of seedlings and accordingly increases the skeleton roots number. High-quality stock material outlet increases, as a result, by 32%.

The most unsafe for selection are Drupaceous (stone-fruit) species which can’t be produced as sanitated planting material because of the viral infection transmission with pollen. That is why along with creation of sanitated plantations for seed storing up of the forms already tested there is a vital necessity of selection work, aimed at the creation of fast-ripening forms, steady against virulent deseases, well-compatible with promising perspective cultivars, possessing a well developed root system, that give vigorous seeds and permit producing root stocks without additional growth.

Seeds sowing immediately after cropping avoids laborious stratification procedure. Nevertheless it is necessary to work out sowing procedure regulations for sowing directly into soil without pericarp removal.

In the sowing procedure of 2002 an average germination in our experiment was 22,6 %. However, as to the studied cherry-plum (*Prunus cerasifera*) forms, planted at the Department of Fruit Nursery fields, there exists essential difference in seed germination.

However, a long-period cherry-plum seedlings investigations permit us to state certain process.

Materials and Methods

At the earliest possible date at these rootstocks young plum plants of high quality and promising varieties can be produced.

At the same time we compared 3 methodics:

- growing of plants by means of winter inoculation with closed root system in heated glass house conditions;

- growing of plants by means of inoculation on the permanent site;
- standard technology of root-stocks growing in seedling school, digging out, planting in the first fruit breeding nursery field and inoculation.

Results and Discussion

Plants growing in glass-houses enables us to get sanitated planting material of plum at the earliest possible date. Period of plants growing with this method constitutes only 388 days.

Standart technology with inoculation in the first nursery field proved to be the most expensive.

Application of scientific system of cherry and sweet cherries nursery proved to be less complicated. Rootstock 'Ismailovsky' can be successfully applied for seedlings stock production, as the rootstock LC-52 – for sweet cherries production. However, correct selection of variety- and root-stock combination is still the most important item in nursery. Rooted grafts of cherry variety 'Vladimirskaya' can be successfully applied in the process of cherry plant growing.

The greatest output is observed with the green grafts of 'Vladimirskaya' var., inoculated with 'Pamiaty Enikeeva' var. (33 thousand /hectare).

Variety `Vladimirskaya` is popular with gardeners and plant-businessmen. That is why if the output from square unit of grafts is 40%, all 100% of plants can be of realized value.

Since sweet cherry acquires more and more importance in Middle Russia horticulture, root stock LC-52 is successfully adopted. It gives greater saplings output compared with cherry 'Vladimirskaya' clone.

Coming back to the scientifically based system of fruit cultures nursery, we can record that the system can easily be integrated into European system of planting material production.

At present Russian Federation is working out a new issue of The Federal law that has been adopted in 1997.

Complicated work that has been carried out by Russian Academy of Agricultural Science, by Ministry of Agriculture, The State Seed Inspection of Russia, leads to elaboration of the most important document.

Conclusions

As a result the fruit culture nursery of Russia proposes the following tasks: to work out and sanitize forms for laying basic clone stock plantations, basic seed and graft plantations; to lay basic clone rootstocks;to work out scientific-proved crop rotations and technologies; to train qualified staff and specialists of different ownership nurseries.

Solution of these tasks will make it possible to create basic nurseries that will supply regions, producing the adoptive variety's grafts, stocks of high quality and sprouts.

Planting material quality control will be much easier as all the material is certified, documented and attended by profile scientific institutes.

Now the leading role of The All-Russian Institute of Breeding Technologies in Horticulture becomes evident, as it not only presents itself as elaborator of all scientific and standard documentation, but also manages construction of glasshouses, what is the most important for basic material production for all regions of Russia. It is also the leader in adaptogenetic and nano-material technology elaboration, in connection with energy- and resource- preserving technologies.

References

1. Борисова А.А., Бешнов Г.В., Фахрутдинов А.А. (2005) Соавместное воздействие физических и биологических факторов на развитие семенных подвоев груши. - «Плодоводство и ягодоводство России»/ Сб. науч. работ ВСТИСП. Москва, т.12, 371-376.
2. Makosz E. (1998) Stan i perspectywy polskiego sadownictwa//Sadownictwo w krajach srodkowo-wschodniej Europy.- Lublin, 3-18.

FRUIT TREE NURSERIES IN LITHUANIA: PROPAGATION AND CERTIFICATION SYSTEM
KOKAUDZĒTAVAS LIETUVĀ: AUDZĒŠANAS UN SERTIFIKĀCIJAS SISTĒMA

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Kopsavilkums

Sertificēta stādāmā materiāla ražošanas sistēma Lietuvā tika atjaunota 1995. gadā. Par kvalitātes kontroli un sertifikācijas sistēmu atbild Valsts sēklu un graudu serviss. 2002. - 2004. gados tika saskaņota juridiskā bāze ar ES likumdošanu. 2005. gadā bija reģistrētas 45 sertificētu stādāmo materiālu ražojošas kokaudzētavas. Ik gadus izaudzē virs 500 000 augļukoku stādu, virs 5 miljoniem upeņu un ap 700 000 zemeņu stādu. 211 kokaudzētavas reģistrētas fitosanitārajā reģistrā un saņem augu pases. 2004.gadā augstāko kategoriju stādāmā materiāla centrs tika izveidots Lietuvas Dārzkopības institūtā. Šis centrs apgādā kokaudzētavas ar vīrusbrīvu potzaru un potcelmu materiālu sertificēta stādu materiāla ražošanai.

Abstract

Certification of fruit plant propagating material in Lithuania was renewed in 1995, when a tree nursery quality program was initiated. State seed and grain service (SSGS) is responsible for the quality control of the planting material, maintenance of propagation steps and the certification system. The legal base according EC directives was harmonised during 2002-2004. 43 nurseries were registered at SSGS as suppliers of certified fruit planting material in 2005. The annual production of certified fruit trees is more than 500 thousands, currants – more than 5 million, strawberries – around 700 thousand. The state plant protection service (SPPS) is responsible for controlling of quarantine pests and diseases in all propagation steps. 211 nurseries are registered in the Phytosanitary register at SPPS and receive Plant passports for propagated material. In 2004 Elite Plant Propagation Centre (EPPC) was established at the Lithuanian Institute of Horticulture in Babtai. EPPC is equipped with a modern screenhouse, virus testing laboratory, thermotherapy and propagation facilities. EPPC is responsible for propagation and maintenance of prebasic and basic propagation material of fruit cultivars and rootstocks and is obligated to supply commercial nurseries with virus free scion and rootstock material for the propagation of certified fruit trees.

Key words: fruit plants, propagation, certification, quality

Introduction

Fruit and berry production takes an important place in the agriculture of the Lithuania. The quality and health status of planting material to a large extent determined the results in the cultivation. Virus or virus like pathogens reduces the usefulness of the propagating material. The European Community introduced rules that guarantee the quality and plant health of the fruit plant propagating material (Council Directive 92/34/EEC, 1992) the Quality of fruit planting material is checked during the official certification. Certification is carried out by competent authorities during controls and field inspections.

All suppliers of fruit planting material are responsible to fulfil certain conditions laid down in the legislation. It is very important for each member state to harmonize legislation, to insure uniform application of the standards and to insure free market for planting material across the Europe.

The aim of work is to describe and discuss the certification and propagation system of fruit and berry plants in Lithuania.

Materials and Methods

The work was performed summarizing the experience and the accumulated knowledge on propagation and certification system at the Lithuanian Institute of Horticulture, State Seed and Grain Service, State Plant Protection Service. National and European Community legislation was analysed. Analysis of fruit plant propagation was performed by an annual questionnaire of commercial nurseries.

Results and Discussion

Legislation. Legal acts describing procedures, responsibilities, quality requirements of planting material, propagation and certification of fruit plants in Lithuania are harmonised according EC directives. Implementation of EC legal requiremwnts took place during 2002-2004. Themain legal acts are following: Law on Seed cultivation (2004), Mandatory requirements for fruit and berry propagating material (2004), Law on the Protection of Plant Varieties (2001), Inspection rules for field inspection of fruit plant propagating material (2005), Law on Phytosanitary (2003), Ministry order on attestation of suppliers of plant propagating material (2002).

Harmonisation of the legislation creates a framework and the conditions for the free marketing of the plant material, meeting the requirements, inside the EU. However competition in the European market is not on legislation, which is only a precondition, but on the quality of the product. Only high quality planting material: virus free, true-to-type and produced under independent official certification could be competitive.

Certification. Certification of fruit planting material in Lithuania was renewed in 1995 by mutual initiative of the Lithuanian Institute of Horticulture (LIH), the Lithuanian Association of Commercial Orchards ‘Fruit and berries’ (ACON) and State Seed and Grain Service under the Ministry of Agriculture (SSGS). At this time state financed tree nursery quality program was initiated. Main nurseries of ACON received high quality (mainly basic) rootstock material for the establishment of rootstock propagation plantations and basic scion material for the establishment of scion shoot orchards from Netherlands, Germany, Poland and Russia. Rootstocks were distributed to nine nurseries all over the Lithuania and scion shoot orchards were planted in three nurseries. At this moment the main idea of certification was to distinguish planting material propagated in certified nurseries and support growers who use certified planting material for the establishment of commercial orchards and berry plantations (Ministry order on aid for certified planting material, 2005). Certification of planting material was performed by SSGS and scientists from LIH. Experts from LIH were involved in the certification of fruit planting material until 2002.

Nowadays SSGS controls propagating material supplied to consumers in the domestic market and its conformity with requirements established by legal acts, implements State quality control of propagating material, implements management of aid for users of certified plant propagating material, controls the preparation of business entities to supply plant propagating material to the internal market, controls conformity of plant propagating material with established requirements, is responsible for the maintenance of propagation steps and the certification system and the issue of quality certificates (http://www.vsgt.lt).

SSGS is a government institution that was established in the middle of the year 2000 after the re-organization of the State Seed Inspection and the State Grain Inspection. SSGS has a main office in Vilnius and four branch offices in regions and employs 114 persons. 10 inspectors are specialised in quality control and certification of fruit propagating material. Qualification of SSGS inspectors especially rose during 2002-2004 when the Lithuanian – Netherlands project PSO01/LT/9/3 ‘The creation and implementation of a monitoring system for the quality of fruit propagating material in Lithuania according to EU requirements’ was implemented. From Lithuanian side partners of the project were SSGS, LIH and ACON, from Netherlands side – Naktuinbouw and Vermeederingstuinen Netherland. During the project not only legal basis was harmonised, but also training courses and practice for specialists and inspectors were organised both in Lithuania and Netherlands. At the same time the improvement of laboratory of SSGS was performed. The laboratory was equipped by modern virus testing PSR equipment.

Only registered nurseries at SSGS can certify propagated planting material. In order to be included into the register nurseries have to fulfil special requirements for nursery management, persons responsible for propagation and documentation, facilities, document keeping, origin of propagating material, registration of all activities, detailed plan or production and etc.

Certification of planting material is performed in few steps:

- nursery information on the amount of propagating material, its category, field plans and planting schemes;
- documentation control;
- one or two field inspection according to the type of planting material;
- labelling;

- batch control;
- issue of certificates.

Planting material is certified if it derives from motherstocks that are thoroughly checked for their identity and virusstatus, is true-to-type and fulfils all phytosanitary requirements. Therefore certified nurseries must be registered at State Plant Protection Service (SPPS) too (Law on Phytosanitary, 2003; Rules for plant passport and protected zones, 2003). Certification of SSGS is not performed if SPPS did not performed inspection on quarantine pests and diseases and soil nematodes. There are attempts to unite the information necessary for plant passport and certification in one label. The SSGS controls all steps of propagation and maintenance of necessary procedures and issues quality certificates not only for certified planting material produced in commercial nurseries but also for basic propagating material that is propagated at the Elite Plant Propagation Centre (Centre).

Propagation system. Certified planting material must arrive from known sources, to be tracebile and controlled at all propagation steps. Therefore Lithuania has started to create the infrastructure necessary for the production of high quality fruit planting material. The elite Plant Propagation Centre is established at the Lithuanian Institute of Horticulture and is responsible for propagation and maintenance of highest quality propagating material and its supply for commercial nurseries for further propagation of certified planting material. At this moment the EPPC is supported by State (at propagation stages: candidate Plant, prebasic material, basic material) and partly by nursery growers (at propagation stages: rootstocks basic material and scion wood orchard). The coordinating committee of the Elite Plant Propagation Centre rules the activities of Centre. There are seven members of Coordinating committee: 2 representatives from commercial nurseries, 2 representatives from commercial orchards, 2 representative from LIH and one from the Ministry of Agriculture. The coordinating committee establishes species and varieties for propagation, determines quantities of material to be propagated, settles the price for scions and rootstocks needed for propagation of certified plants in commercial nurseries, decides distribution of propagating material in the case of shortages. During the project 'The creation and implementation of a monitoring system for the quality of fruit propagating material in Lithuania according to EU requirements' implementation a modern screen house for the maintenance of prebasic material was build at the Lithuanian Institute of Horticulture. The Centre uses the virus testing laboratory, thermoterapy chambers and propagation facilities of LIH.

In order to speed the implementation of the propagation and certification system Centre had the oportunity to receive prebasic planting material of apple, cherry, plum and pear from Vermeederingstuinen Netherland. Scion shoot orchard established with certified mother trees from the same source supply all Lithuanian nurseries with scions needed for propagation of certified planting material (Table 1).

Table 1. Fruit plant propagation system in Lithuania, activities and institution involved

Propagation steps	Activities	Place	Control
Candidate plant	Full testing, testreports of individual plants	Centre	Annual auditing of the laboratory by SSGS
Prebasic material	Maintenance and propagation	Centre	Auditing system, facility check, random viruschecks of motherplants by SSGS
Basic material	Maintenance, propagation, pomological control	Centre	Inspection, random viruschecks by SSGS and SPPS, issue of certificates
Certified scion wood material	Propagation	Centre	Field inspection, random viruschecks by SSGS and SPPS, issue of certificates
Certified rootstock material	Propagation	Centre and commercial nurseries	Field inspection, random viruschecks by SSGS and SPPS, issue of certificates
Certified plants	Propagation	Commercial nurseries	Field inspection, random viruschecks by SSGS and SPPS, issue of certificates

Basic rootstocks for the establishment of rootstocks of propagation fields are distributed to commercial nurseries, that propagate certified rootstocks. Rootstock nurseries propagate rootstocks not only for their own needs but also supply other nurseries with certified rootstocks for the production of certified trees.

Suppliers of uncertified fruit and berry planting material do not follow this propagation system but there are attempts to involve them to a larger extent. Already suppliers of uncertified fruit and berry planting material must be registered at the SPPS in order to receive a plant passport. The marketing of fruit planting material without a plant passport is restricted. In 2005 211 fruit and berry nurseries were registered at Phytosanitary register (Rules for plant passport and protected zones, 2003; http://www.vaat.lt). From 2005 they have also to be registered at SSGS and fulfil minimum requirements for CAC quality material (Ministry order on attestation of suppliers of plant propagating material, 2002).

Propagation. During 1995 – 2005 the number of certified nurseries increased from 9 up to 43. 10 nurseries propagate all species of fruit and berry plants, 33 nurseries are specialised in propagation of currants and/or strawberries. The main fruit crops in Lithuania are apples, black currants and strawberries. Certified nurseries in most cases fulfil the demand of fruit planting material.

Total production of apple planting material have tendency to annual increase (Fig 1).

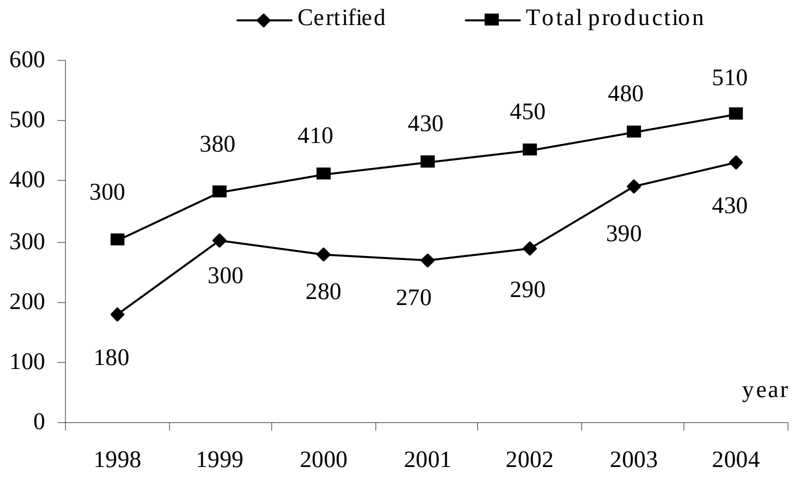

Figure 1. Total production and production of certified apple planting material in Lithuania, thousands

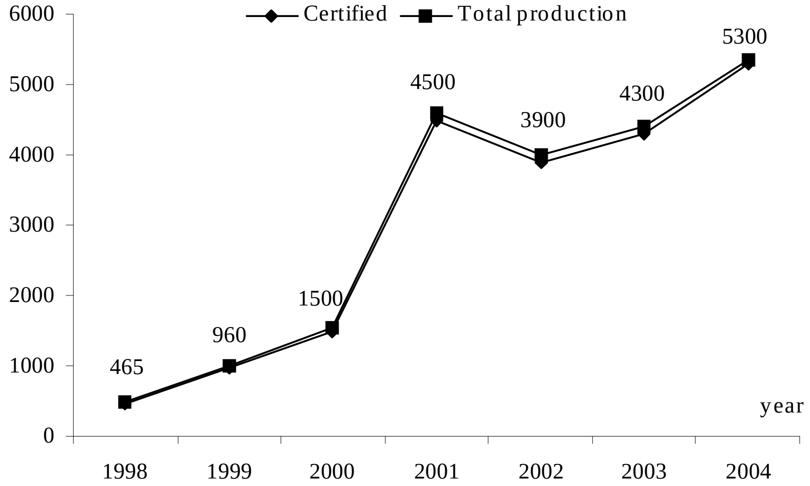

Figure 2. Total production and production of certified black currant planting material in Lithuania, thousands

Production of certified apple planting material was rather stable during the period of 1999-2002 – around 300 thousands trees were produced annually. A big rise in production was recorded in the last two years. The situation was unclear because State aid paid was paid commercial orchards that use certified planting material for the establishment of new plantations. At the same time production of uncertified apple planting material declined due to loss of demand from for amateurs gardeners.

The amateur market for black currants is less than apples therefore mostly certified planting material is produced (Fig.2). A big expansion of black currants production lasted until 2001 when it reached four and half million bushes but even until now it remained stable despiterm low prices of black currants berries. In the near future a decrease in propagation of black currants is expected.

A different situation exists in propagation of certified strawberry planting material (Fig. 3). Since State aid is relatively low for strawberries planting material there was no stimulation to use certified material. In such a situation most of strawberry nurseries are trying to avoid certification and the control of official institutions. Almost 3 millions strawberries were propagated in 2004, but only 690 thousands were certified. At the same time large imports of strawberry planting material exists from Poland. Propagation of uncertified planting material will decrease only whan growers will be aware of the quality and health status of planting material.

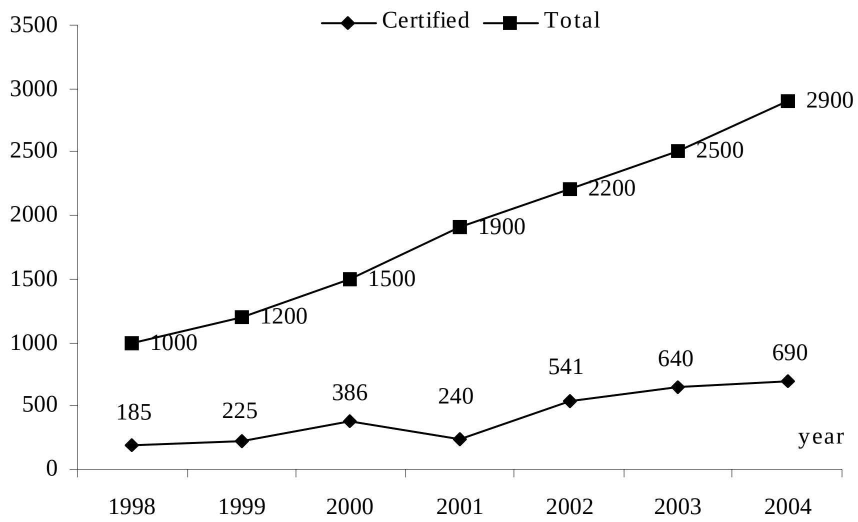

Figure 3. Total production and production of certified strawberry planting material in Lithuania, thousands

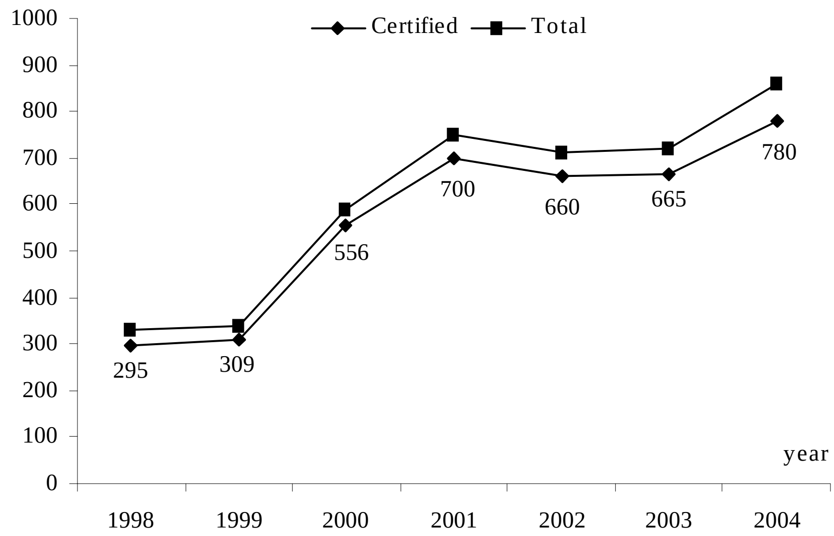

Figure 4. Total production and production of certified apple vegetative rootstocks in Lithuania, thousands

Conclusions

Legislation on the certification of fruit and berry planting material according EC directives has been created in Lithuania. State seed and grain service under the Ministry of Agriculture is responsible for the maintenance of propagation steps and the certification system.

43 certified nurseries produce annually 500 thousand certified fruit trees, 5 million currants and 700 thousand strawberries and meet demand of commercial orchards.

The elite Plant Propagation Centre is established at the Lithuanian Institute of Horticulture and is responsible for the propagation and maintenance of prebasic and basic propagation material and supplying the commercial nurseries of Lithuania with virus free propagating material.

References

1. Council Directive 92/34/EEC of 28 April 1992 on the marketing of fruit plant propagating material and fruit plants intended for fruit production. (1992) Official Journal,L 157, 0010 – 0018.
2. http://www.vaat.lt.
3. http://www.vsgt.lt.
4. Inspection rules for field inspection of fruit plant propagating material (2005) Valstybės žinios, No. 72-2644.
5. Law on Phytosanitary (2003) Valstybės žinios, No. 102-4583 (in Lithuanian).
6. Law on Seed Cultivation (2004) Valstybės žinios, No. 156-5687 (in Lithuanian).
7. Law on the Protection of Plant Varieties (2001) Valstybės žinios, No. 104-3701 (in Lithuanian).
8. Mandatory reguirements for fruit and berry planting material (2004) Valstybės žinios, No. 78-2734 (in Lithuanian).
9. Ministry order on aid for certified planting material (2005) Valstybės žinios, No. 39-1272 (in Lithuanian).
10. Ministry order on attestation of suppliers of plant propagating material (2002) Valstybės žinios, No. 79-3349 (in Lithuanian).
11. Rules for plant passport and protected zones (2003) Valstybės žinios, No. 81(1)-3711 (in Lithuanian).

INDUCTION OF FEATHERING OF APPLE PLANTING MATERIAL
SASTEIGTO DZINUMU VEIDOŠANĀS SEKMĒŠANA ĀBEĻU STĀDIEM

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Kopsavilkums

Lietuvas Dārzkopības institūtā 2001 -2003 gados tika veikti izmēģinājumi, kuros pārbaudīja sasteigto dzinumu veidošanos viengadīgiem ābeļu stādiem. Tika pētītas triju grupu šķirnes: 'Jonagold' un 'Aldas', kuras viegli veido sasteigtos dzinumus; 'Auksis', 'Rubin' un 'Alwa', kuras parasti pirmajā gadā neveido sasteigtos dzinumus; 'Shampion' un 'Ligol', kuras vidēji spēcīgi veido sasteigtos dzinumus. Sānu dzinumu veidošanu stimulēja pielietojot augšanas regulatoru Arbolin 36SL (BA+GA_3) un galvenā dzinuma galotņošanu, vai lietoja abas metodes kombinēti. Visu apstrādes veidu lietošana šķirnēm, kuras viegli veido sāndzinumus, būtiski palielināja stādu kvalitāti. 'Shampion' un 'Ligol' stādu kvalitāte uzlabojās lietojot tikai augšanas regulatorus vai abas metodes kombinēti. Šķirnēm, kuras ģenētiski vāji veido sāndzinumus, jāpielieto abu metožu kombinācija.

Abstract

In 2001-2003 nursery trials were conducted at the Lithuanian Institute of Horticulture. The aim of the trial was to test apple cultivars and different treatments in order to increase the lateral branching of one year old trees at North European climatic conditions. Three types of cultivars were included: 'Jonagold' and 'Aldas' that one year old trees easily form feathers; 'Auksis', 'Rubin' and 'Alwa' that do not form feathers during the first year; 'Sampion' and 'Ligol' that belong to intermediate type. Feathering was stimulated by growth regulator Arbolin 36SL (BA+GA_3), pinching of terminal leaves or combination of both factors. Maiden trees were assessed for height, percentage of trees with laterals, number of laterals and spurs, shoot length. All treatments for cultivars with easy feathering habit stimulated production of high quality maidens. Application of growth regulator or it combination with pinching of terminal leaves were the best treatments for 'Sampion'and 'Ligol', while only pinching did not gave sufficient quality every year. In order to produce one-year-old feathered trees of cultivars that do not form feathers naturally, application of growth regulators together with pinching of terminal leaves should be applied.

Key words: *Malus* x *domestica*, nursery, lateral branches, quality, growth regulators.

Introduction

Quality of planting material is key factor for an early crop in the orchard and quick economic returns. For intensive orchards feathered trees are preferred (Bootsma and Baart, 1990; Poniedzialek *et al*., 1994). The most popular type of apple planting material in West and Central European nurseries is a two-year-old tree with a one-year-old crown (knip type tree) (Bielicki *et al*., 2002; Bielicki and Czynczyk, 1999). In North Europe due to differences in vegetation period, sum of temperatures and cultivars choice, the quality of the knip type tree is still under discussions, so that is why traditionally trained two-year-old tree is still prevailing there.

Because of economical reasons, nurserymen prefer to grow one-year-old trees. But not all apple cultivars grown as one-year-olds are suitable for the establishment of intensive orchards, since they do not produce lateral branches (Bootsma and Baart, 1990; Kviklys, 2004). Chemical agents or other techniques could induce feathering of one year old maidens. 6-benzyladenine (BA) and gibberellic acid (GA) are the most common plant growth regulators that promote formation of lateral branches (Buban, 2002; Hrotko *et al*., 2000; Jacyna 2001; Wertheim and Estabrooks, 1994). They are successfully applied for different fruit crops (Jacyna and Puchala, 2004; Magyar and Hrotko, 2005 and Neri *et al.*, 2004). Trials on concentration of regulators, terms and the number of repetitions of application were conducted in different countries (Magyar and Hrotko, 2002; Jacyna, 1996; Theron *et al*., 2000; Wertheim and Estabrooks, 1994). In North European climate conditions, do not every season apple maidens reach recommended height needed for application of plant growth regulators, therefore other treatments as pinching of terminal leaves should be tested. Until now there are no publications presenting trials performed in climatic conditions similar to Lithuania.

The aim of the trial is to test reaction of various apple cultivars to treatments that induce feathering and to compare the efficiency of different treatments.

Materials and Methods

Nursery trials were conducted at Lithuanian Institute of Horticulture in 2001-2003. Maidens of apple cultivars 'Aldas', 'Alwa', 'Auksis', 'Jonagold', 'Ligol', 'Rubin', and 'Sampion' on rootstock M9 were tested. Rootstocks were planted at 0.9x0.3 m distance and budded at the beginning of August 2001 and 2002. Treatments inducing formation of lateral branches were applied during the following year at the end of June – beginning of July (2002 and 2003). Plant growth regulator Arbolin 36SL ($BA+GA_3$) at concentration 25 ml l^{-1} was sprayed once when the maidens reached 55-65 cm height. Arbolin was applied at the top part of these maidens. Pinching of terminal leaves leaving apical growing point intact was started at the same time and was repeated 4 times at weekly intervals. The third treatment was a combination of Arbolin and pinching of terminal leaves. Control trees were left intact. All feathers appearing lower than 70 cm above the ground were removed immediately after their emergence.

At the end of the vegetation, percentage of feathered trees was calculated, where maidens with at least three feathers higher than 70 cm above the ground were considered as feathered. Tree height and trunk diameter (at 30 cm) was measured. The number and length of feathers longer than 10 cm, number and length of spurs below 10 cm, and total lateral shoot length was calculated.

Vegetation conditions during the two years of the experiment were comparable. Temperature was higher than the year's average in April and May, which promoted bud brake and fast growth of maidens. The temperature of July exceeded the years' average by 3 degrees and induced better feathering. Higher temperatures stayed in August 2002, but were lower in August 2003. Precipitations were more abundant in July and August 2003, which benefited to slightly better feathering. Since there were no interactions between years and tendencies of feathering were the same, the results are presented as an average of two years.

The trial was set up in 4 replications with 30 trees per replicate. Differences between treatments and cultivars were estimated by two-way analysis of variance.

Results and Discussion

Combined treatment the pinching of terminal leaves and the application of Arbolin - was the most effective in breaking the dormancy of summer buds of one-year-old apple nursery trees, though there were no significant differences compared to treatment with Arbolin for cvs. 'Sampion', 'Ligol', 'Jonagold', and 'Aldas' (Table 1). Later two cultivars had 100% of feathered trees when only pinching was done.

Table 1. Effect of different treatments on the percentage of feathered trees, %

Cultivar	Treatment			
	pinching	Arbolin	pinching+Arbolin	control
'Auksis'	0	82	100	0
'Sampion'	78	100	100	23
'Jonagold'	100	100	100	80
'Aldas'	100	100	100	78
'Ligol'	34	87	97	22
'Alwa'	3	63	97	0
'Rubin'	0	0	70	0

Cultivar $LSD_{0.01}$ – 16.2; treatment $LSD_{0.01}$ – 12.6; cultivar x treatment $LSD_{0.01}$ – 24.5

Naturally branched 80% of maidens of cvs. 'Jonagold' and 'Aldas', and only 22-23% of cvs. 'Sampion' and 'Ligol'. Control and pinched trees of cv. 'Auksis' and 'Rubin' did not form laterals at all. Only 3% of cv. ‘Alwa’ maidens feathered when pinching of terminal leaves was performed, but it could be induced by occasional damage of apical growing point.

Cv. ‘Rubin’ did not respond to branching inducing treatments and even in combined treatment had a significantly lower percentage of feathered trees than other cultivars.

Table 2. Effect of different treatments on number of shoots longer than 10 cm

Cultivar	Treatment			
	pinching	Arbolin	pinching+Arbolin	control
‘Auksis’	0	6.0	7.1	0
‘Sampion’	3.4	8.6	9.2	0.4
‘Jonagold’	8.4	10.2	9.7	4.5
‘Aldas’	7.2	9.5	10.8	4.2
‘Ligol’	1.3	3.1	5.0	1.0
‘Alwa’	0.2	3.0	6.2	0
‘Rubin’	0	0	3.4	0

Cultivar $LSD_{0.01}$ – 1.85; treatment $LSD_{0.01}$ – 1.31; cultivar x treatment $LSD_{0.01}$ – 2.52

Treatments that determined higher percentage of feathered maidens increased the number of laterals longer than 10 cm too. On average, the most numerous laterals (7.2) were formed when pinching and Arbolin were combined (Table 2). At this treatment cv. ‘Alwa’, ‘Ligol’, and ‘Rubin’ had the most significant increase of feathers compared to other treatments. ‘Jonagold’, ‘Aldas’, and ‘Sampion’ had more feathers than other cultivars after the application of Arbolin and combined treatment. ‘Sampion’ had significantly less feathers than ‘Jonagold’ and ‘Aldas’ in control and pinching treatment. There were no significant differences between Arbolin and the combined treatment for cvs. ‘Sampion’, ‘Jonagold’, ‘Aldas’ and ‘Auksis’. Cv. ‘Rubin’ had significantly less sylleptic shoots than other cultivars included in the trial.

Effect of treatments on spurs formation was less pronounced and no significant differences occurred when cultivars or treatments were compared. On average, somewhat more spurs developed when Arbolin or pinching+Arbolin were applied (Table 3). Though mainly these differences were caused by cultivars that did not form feathers in control and pinching treatments. Reaction of cv. ‘Sampion’, ‘Jonagold’, ‘Aldas’, and ‘Ligol’ to different treatments was not adequate.

Table 3. Effect of different treatments on the number of spurs

Cultivar	Treatment			
	pinching	Arbolin	pinching+Arbolin	control
‘Auksis’	0	1.4	1.7	0
‘Sampion’	1.7	0.4	2.5	1.0
‘Jonagold’	0.4	1.6	1.4	1.3
‘Aldas’	0.5	1.5	2.0	1.0
‘Ligol’	0.6	1.6	1.1	0.9
‘Alwa’	0.1	0.1	1.3	0
‘Rubin’	0	0	0.3	0
Mean	0.5	1.0	1.4	0.6

Cultivar not significant (NS); treatment NS; cultivar x treatment NS

Total shoot length varied upon cultivar and correlated with a number of feathers longer than 10 cm. ‘Jonagold’ and ‘Aldas’ had the biggest shoot growth in all treatments (Table 4). Pinching increased total shoot length for ‘Sampion’, ‘Jonagold’, and ‘Aldas’ compared to control, but it was not effective for other tested cultivars. Application of Arbolin was superior to pinching treatment for all cultivars. The combination of pinching and Arbolin significantly increased total shoot length for cvs.

'Sampion', 'Aldas', 'Ligol', and 'Alwa'. Total shoot growth of cv. 'Jonagold' was better after application of Arbolin.

Table 4. Effect of different treatments on total shoot length, cm

Cultivar	Treatment			
	pinching	Arbolin	pinching+Arbolin	control
'Auksis'	0	125.2	133.2	0
'Sampion'	78.7	176.3	243.5	14.5
'Jonagold'	205.7	314.0	299.0	93.7
'Aldas'	197.2	270.0	320.5	87.2
'Ligol'	27.3	55.5	112.3	21.3
'Alwa'	5.3	95.3	210.3	0
'Rubin'	0	0	76.3	0
Mean	73.5	149.2	198.2	31.0

Cultivar $LSD_{0.01}$ 15.62; treatment $LSD_{0.01}$ 12.75; cultivar x treatment $LSD_{0.01}$ 31.24

Pinching of terminal leaves and Arbolin did not increase the mean shoot length of cv. 'Ligol' compared with control (Table 5). For other cultivars all branching inducing treatments gave longer sylleptic shoots than the control trees. For 'Jonagold' and 'Aldas' Arbolin and combined treatments were superior to pinching. For cv.'Sampion' pinching and combined treatment resulted in longer laterals. Arbolin and combined treatment bore very similar results for other cultivars and no significant differences were recorded between them. Significantly longer laterals grew on maidens of cvs. 'Sampion', 'Jonagold', 'Aldas' and 'Alwa' compared with other cultivars.

Table 5. Effect of different treatments on mean shoot (longer than 10 cm) length, cm

Cultivar	Treatment			
	pinching	Arbolin	pinching+Arbolin	control
'Auksis'	-	19.0	21.3	-
'Sampion'	24.2	20.6	26.7	12.3
'Jonagold'	24.2	30.8	30.8	18.1
'Aldas'	23.2	28.2	29.5	17.2
'Ligol'	15.4	17.4	21.8	13.6
'Alwa'	-	32.6	34.2	-
'Rubin'	-	-	23.2	-
Mean	21.8	24.8	26.8	15.3

Cultivar $LSD_{0.05}$ – 6.56; treatment $LSD_{0.05}$ – 3.82; cultivar x treatment - n.s.

Between tested cultivars great differences exist in response to applied treatments. For apple cultivars with easy branching habits every treatment was sufficient to increase the percentage of feathered trees. Cultivars that normally do not produce lateral branches during the first year in the nursery had different response to treatments. Arbolin alone was not an effective treatment to cv. 'Rubin'. Similar results are reported by Sadowski and Gorski (2003) for cv. 'Gloster', that develops few and short feathers in spite of treatment with Arbolin. For such cultivars more application of plant growth regulators might be needed to increase the percentage of feathered trees as is reported in different trials (Hrotko *et.al.*, 1997; Jacyna, 2001; Magyar and Hrotko, 2005; Wertheim and Estabrooks, 1994). Pinching of terminal leaves did not increase sufficiently the percentage of feathered trees of cvs. 'Rubin', 'Auksis', 'Alwa' and 'Ligol'. For these cultivars combination of Arbolin and pinching of terminal leaves was the best treatment. Only 20% of cv. 'Sampion' and 'Ligol' feathered naturally though there is information on good branching habits of these cultivars.

The combination of Arbolin and pinching significantly increased the number of laterals for all tested cultivars that are very important for the establishment of intensive orchards (Bielicki and

Czynczyk, 1999; Bootsma and Baart, 1990; Sadowski *et al*., 2003). Cvs. 'Alwa', 'Ligol' and 'Rubin' had the highest response for this treatment. Cvs. 'Jonagold' and 'Aldas' had almost the same number of laterals treated by Arbolin alone or when pinching was applied. A surprisingly high efficiency of Arbolin was recorded for cv. 'Auksis', which do not form feathers during the first year in the nursery. Six shoots obtained after one treatment with Arbolin could be comparable with repeated sprays by other plant growth regulators in some trials performed with difficult to feather cultivars (Wertheim and Estabrooks, 1994). For cv. 'Sampion' Arbolin was also more effective compared with pinching.

Treatments inducing branching had no effect on the development of spurs. Short laterals usually form flower buds on the top and are important for first yields in the orchard (Bielicki and Czynczyk, 1998). Application of Arbolin only once per season and other treatments seems to be insufficient for spur formation. Regular application of plant growth hormones could increase the number of laterals with flower buds, what is reported for apples (Buban, 2000) and cherries (Magyar and Hrotko, 2005), though contradictary results are obtained too (Wertheim and Estabrooks, 1994). Application of higher concentrations of BA, which was not tested in our trial, also benefits to short laterals formation (Magyar and Hrotko, 2002; Wertheim and Estabrooks, 1994).

Total shoot length correlated with the number of laterals. Total shoot length more than 3 m of cvs. 'Jonagold' and 'Aldas' that had the highest number of laterals is less than reported in other trials (Wertheim and Estabrooks, 1994). These differences could be caused by the length of the vegetation season. On the other hand in our trial only laterals that emerged higher than 70 cm above the ground were measured.

The average length of sylleptic shoots was increased in most cases when plant growth regulator Arbolin 36SL was applied. Pinching alone did not have such positive effect on average shoot length. The length of laterals depended on the genotype. Cultivars with better branching habits formed longer shoots. The exception was cv. 'Alwa' which formed few but long laterals.

Conclusions

Up to 100% of feathered one-year-old apple trees of cvs. 'Jonagold' and 'Aldas' could be obtained in the nursery when plant growth regulator Arbolin 36SL or pinching of terminal leaves is applied.

Pinching of terminal leaves four times in weekly intervals is not an effective treatment to obtain feathered trees of cvs. 'Auksis', 'Rubin', 'Alwa' and 'Ligol'.

Application of Arbolin 36SL or a combination of Arbolin 36SL and pinching of terminal leaves sufficiently induce feathering of apple maidens of cvs. 'Sampion' and 'Ligol'.

The combined application of the growth regulator together with pinching of terminal leaves is needed for cvs 'Auksis', 'Rubin' and 'Alwa' in order to produce one-year-old planting material of high quality.

On average for all apple cultivars combination of Arbolin 36SL and pinching of terminal leaves increased the number of sylleptic shoots and total shoot length.

References

1. Bielicki P., Czynczyk A. and Nowakowski S. (2002) Influence of plant material quality on growth and yield of two apple cultivars. Horticulture and Vegetable Growing, 21 (4), 33-38.
2. Bielicki P. and Czynczyk A. (1999) Drzewka jabloni do nowoczesnych sadow XXI wieku. Zeszyty naukowe AR Krakow, 66, 59-65.
3. Bielicki P. and Czynczyk A. (1998) Mozliwosci modelowania jakosci drzewek dwuletnich. Materially XXXVII ogolnopolskiej naukovej konferencji sadowniczej. Skierniewice, 174-177.
4. Bootsma J. and Baart J. (1990) Choice of half-produced trees is not right. Fruitteelt, 80, 22-23.
5. Buban T. (2000) The use of benzyladenine in orchard fruit growing: a mini review. Plant Growth Regulation, 32, 381-390.
6. Hrotko K., Magyar L. and Ronay Z. (2000) Improved feathering on apple nursery trees by BA application. Acta Horticulturae, 514, 113-122.
7. Hrotko K., Magyar L. and Buban T. (1997) Improved feathering by benzyladenine application on one-year-old 'Idared' apple trees in the nursery. Acta Horticulturae, 451, 673-678.

8. Jacyna T. and Puchala A. (2004) Application of environment friendly branch promoting substances to advance sweet cherry tree canopy development in the orchard. Journal of Fruit and Ornamental Plant Research, 12, 177-182.
9. Jacyna T. (2001) Studies on natural and induced branching in temperate fruit and ornamental trees. Rozprawy naukowe akademii rolnicnzej w Lubline, 246, 45-66.
10. Jacyna T. (1996) Induction of lateral branching in nursery pear and apple trees with plant growth regulators. Fruit Varieties Journal, 50 (3), 151-156.
11. Kviklys D. (2004) Apple rootstock effect on the quality of planting material. Acta Horticulturae, 658 (2), 641-646.
12. Magyar L. and Hrotko K. (2005) Effect of BA (6-benzyladenine) and GA_{4+7} on feathering of sweet cherry cultivars in the nursery. Acta Horticulturae, 667, 417-422.
13. Magyar L. and Hrotko K. (2002) Effect of 6-benzyladenine (BA) and gibberellic acid (GA_{4+7}) application on feathering of plum cultivars in nursery. Acta Horticulturae, 577, 345-349.
14. Neri D., Mazzoni M., Zucconi F. and Dradi G. (2004) Feathering control in sweet cherry (*Prunus avium* l.) nursery, by deblading and cytokinin. Acta Horticulturae, 636, 119-127.
15. Poniedzialek W., Nosal K. and Porebski S. (1994) Wplyw rozgaleziania sie drzewek jabloni w szkolce na ich wzrost i owocowanie w sadzie. Zeszyty naukowe AR Krakow, 21, 59-67.
16. Sadowski A. and Gorski M. (2003) Quality of apple planting stock depending on its method of production. Plant Science, 40, 394-398.
17. Sadowski A., Rybacka I. and Jablonski K. (2003) Initial growth, yield and fruit quality of “Gloster” apple trees, depending on the type of one-year-old nursery trees used for planting. Horticulture and Vegetable Growing, 22 (4), 60-67.
18. Theron K.I., Steyn W.J. and Jacobs G. (2000) Induction of proleptic shoot formation on pome fruit nursery trees. Acta Horticulturae, 514, 239-244.
19. Wertheim S. J and Estabrooks E .N. (1994) Effect of repeated sprays of 6-benzyladenine on the formation of sylleptic shoots in apple in the fruittree nursery. Scientia Horticulturae, 60, 31-39.

USING OF GROWTH STIMULATOR "AUSMA" IN STRAWBERRY PLANT PRODUCTION
AUGŠANAS STIMULATORA "AUSMA" LIETOŠANA ZEMEŅU STĀDU AUDZĒŠANĀ

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Kopsavilkums

Augu augšanas stimulators „Ausma" tika pārbaudīts 2003. un 2004. gadā. 2003. gadā to izmantoja tikai zemeņu rozešu apsakņošanas sākumā 0.2 % koncentrācija šķirnēm `Gerida`, `Jonsok` un `Annelise. Novērotas būtiskas atšķirības starp šķirnēm apsakņošanās izvērtējumā. 2004. gadā divu šķirņu augi 'Kokinskaja Pozdņaja' un 'Jonsok' augi tika apstrādāti ar augšanas stimulatoru "Ausma" ik pēc 10 dienām 0.2 % koncentrācijā un abu šķirņu augi būtiski labāk apsakņojās. 2004. gadā šis preparāts tika izsmidzināts arī uz zemeņu mātesaugiem (Mo paaudze), lai novērtētu preparāta ietekmi uz augu attīstību un stīgu veidošanos divām šķirnēm `Kokinskaja Pozdņaja` un `Zefyr`. Ausma būtiski palielināja lapu augšanu, stīgu veidošanos un attīstību tikai šķirnei `Kokinskaja Pozdņaja`.

Abstract

The plant growth stimulator "Ausma" was tested on strawberries for two growing seasons: in 2003 and 2004. In 2003 it was applied on strawberry plants at the beginning of rooting one time in 0.2 % concentration. Three different strawberry cultivars were used - `Gerida`, `Jonsok` and `Annelise`. In this year the growth stimulator did not significantly influence strawberry plantlet rooting and development, while there was significant difference between the cultivars. In 2004 growth stimulator "Ausma" was applied three times every 10 days in 0.2 % concentrations. Two strawberry cultivars were used - `Kokinskaya Pozdnaya` and `Jonsok`. Growth stimulators succeeded strawberry plantlet rooting and development for both cultivars. The growth stimulator "Ausma" was applied also on strawberry mother plants propagated *in vitro* (Mo generation) in 2004, to evaluate the influence on plant growth and runnering. Two strawberry cultivars were used - `Kokinskaya Pozdnaya` and `Zefyr`. Significantly different reactions to the growth stimulator were observed. "Ausma" did not influence plant development and runnering of cultivar `Zefyr`, while it significantly succeeded leaf growth, runnering and runner development for cultivar the `Kokinskaya Pozdnaya`.

Key words: *Fragaria x ananasssa* Duch., growth stimulator, runnering, rooting, plant growth, cultivar.

Introduction

Due to the activities for the reduction of enviromental pollution and the increasing of human health status the interest on using of new natural products in plant growing is increasing. Investigations about chemical composition and using possibilities of pine and spruce needle water extracts were started in 1988 in the Latvian Forest Research Institute. The first investigations showed positive influence of the stimulator on the growth, flowering and productivity of different plants. The Latvian enterprise Biolat Ltd was worked out a natural plant growth stimulator "Ausma". It is the coniferous needles' water extract, which contains a lot of different phenols, albumins, organic acids, carbohydrates, micro and macro elements, vitamins etc. Tests about needle extract activity on the camomile, carnation, sweet peas, lettuce, cucumber, cabbage and barley was made in the Institute of Biology and abroad (Webb, 2004 and Place, 2004). The use of extract showed stimulation activity on the development of buds, flowers and root system like phytohormones of cytokinins group. The testing of `Ausma` on strawberries was started at the Pūre Horticultural Research Station in 2003, to evaluate the influence of this product on plant development, runnering and rooting.

Materials and Methods

The plant growth stimulator "Ausma" was tested on strawberries for two growing seasons: in 2003 and 2004 in the Pūre Horticultural Research Station, Latvia. In 2003 the experiment was carried out from August 14 to September 15. Strawberry plantlets with the first root nodules visible and short runner (about 1.0 cm) attached were cut from the mother plants of Mo generation. Runner plants were potted in plastic trays filled with peat and perlite mixture. The plant growth stimulator "Ausma" was applied on strawberry plants after potting one time in 0.2 % concentration by watering. Plants were grown in a plastic tunnel, regularly watered and sprayed by fungicide Euparen M (one time). Three different strawberry cultivars were used: `Gerida`, `Jonsok` and `Annelise`. The amount of rooted plants and leaves per plant were counted and root length, crown diameter, and total plant weight after rooting were measured. Each plant was considered as replication, in total 20 plants per variant were evaluated.

Another experiment was carried out in 2004. The same type of runner plants and growing media were used. "Ausma" was applied three times every 10 days at the same concentration as in 2003. Two strawberry cultivars were used: `Kokinskaya Pozdnaya` and `Jonsok`. The amount of rooted plants and plant development (amount of leaves, root length, crown diameter, total plant weight before and after rooting) were evaluated. Each plant was considered as replication, in total 20 plants per variant were evaluated.

In 2004, the growth stimulator "Ausma" was also applied on strawberry mother plants of Mo generation, which were grown in plastic tunnel. Two strawberry cultivars were used - `Kokinskaya Pozdnaya` and `Zefyr`. Plants were planted in May 19 in plastic boxes (14x17.5x78 cm) filled with peat and perlite mixture – three plants per box. Boxes were placed in four rows on different height – 0.3, 0.6, 0.9 and 1.2 m. Growth stimulator "Ausma" was applied one time per month in 0.2 % concentration by watering (250 ml of solution per plant). Leave development and runnering was evaluated. Amount of runner plants suitable for rooting was counted. Each mother plant was considered as replication, in total 12 plants per variant were evaluated.

The data of all experiments were subjected to Analysis of Variance (γ=0.05.).

Results

In the experiment of 2003, the amount of rooted plants after one month of potting varied from 100 to 90 % from total, depending on cultivar and treatment. The difference between treatments and cultivars was not significant. Though in total, the growth stimulator "Ausma" slightly succeeded the rooting of plants - in average 3 % more rooted plants than in control. Cultivar `Annelise` had the best rooting, where all plants were rooted in both of treatments, and cultivar `Gerida` - the lowest rooting (92.5 % of rooted plants from total). The growth stimulator did not influence significantly strawberry runner plant development during rooting, but there was significant difference between cultivars. Cultivar `Gerida` had significantly lower leaf amount and root length than cultivars `Annelise` and `Jonsok` (Table 1). Cultivar `Annelise` had significantly smaller crown diameter, than other cultivars. Cultivar `Jonsok` had the highest total plant weight, root weight and crown diameter.

Table 1.Strawberry plant development after rooting in 2003

Parameter		Leaves, number per plant	Root length, cm	Root weight, g	Total plant weight, g	Crown diameter, mm
Treatment	`Ausma`	3.33	9.57	1.45	3.54	6.03
	Control	2.87	10.40	1.38	3.92	6.10
	LSD $_{0.05}$	0.68	1.47	0.40	0.80	0.84
Cultivar	Gerida	2.60	7.15	1.16	3.09	6.40
	Jonsok	3.20	11.30	1.69	4.21	6.95
	Annelise	3.50	11.50	1.39	3.09	4.85
	LSD $_{0.05}$	0.83	1.80	0.49	0.98	1.03

In the experiment of 2004, cultivar `Jonsok` had all plants rooted in both treatments. Cultivar `Kokinskaya Pozdnaya` had all plants rooted in the treatment with she growth stimulator "Ausma", but in control - 95 % from total. The growth stimulator "Ausma" significantly succeeded the increasing of plant total weight, crown diameter and leaf number for both of tested cultivars (Table 2).

Growth stimulator also succeeded the root development, but not statistically significantly. The difference between cultivars in plant development was not significant.

Table 2.Strawberry plant development after rooting in 2004

Parameter		Leaves, number per plant	Root length, mm	Root weight, g	Total plant weight, g	Crown diameter, mm
Treatment	"Ausma"	4.05	115.0	3.29	7.63	8.30
	Control	3.30	108.1	2.56	5.16	6.70
	LSD $_{0.05}$	0.42	31.3	1.33	2.17	1.48
Cultivar	Kokinskaya Pozdnaya	3.52	120.0	2.65	6.05	7.35
	Jonsok	3.82	103.1	3.20	6.73	7.65
	LSD $_{0.05}$	0.42	31.3	1.33	2.17	1.48

Significantly different reaction to the growth stimulator was observed between cultivars after applying of "Ausma" on mother plants. "Ausma" did not influence leaf amount for cultivar \`Zefyr\`, while it succeeded the leaf development for cultivar \`Kokinskaya Pozdnaya\` (Figure 1).

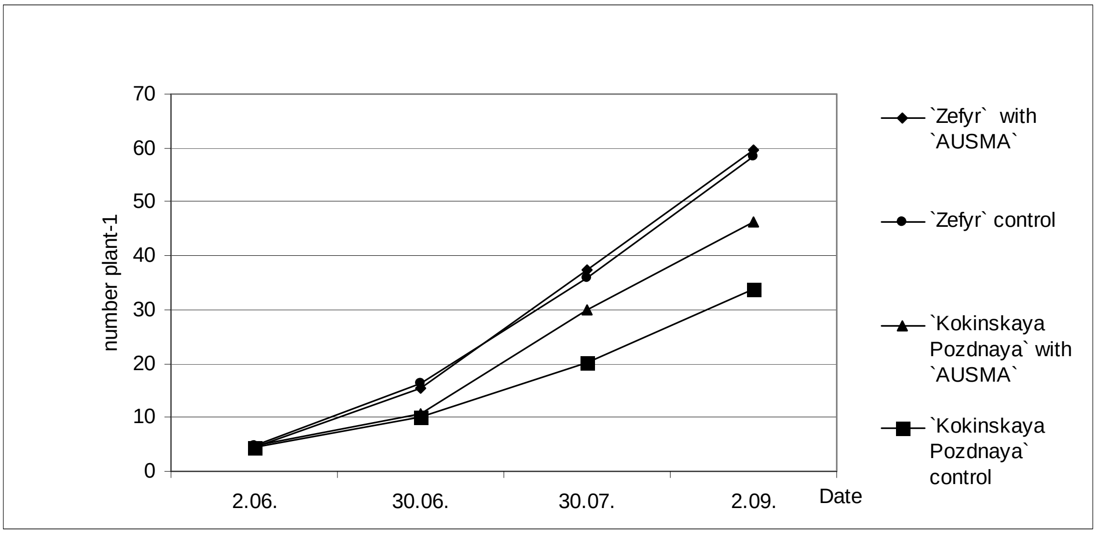

Figure 1. Influence of growth stimulator "Ausma" on leave development of strawberry mother plants for two cultivars

After three month of growth cultivar \`Zefyr\` had significantly higher leaf amount than cultivar \`Kokinskaya Pozdnaya\`.

Runnering intensity at the beginning of summer (during intensive growth of mother plants) increased and at the end of summer decreased (Figure 2). Cultivar \`Zefyr\` had higher runnering intensity than cultivar \`Kokinskaya Pozdnaya\` at the beginning of summer. Later runnering intensity of the cultivar \`Kokinskaya Pozdnaya\` increased, especially in the treatment with growth stimulator "Ausma". "Ausma" did not succeed the runnering intensity for cultivar \`Zefyr\`, but had positive effect on cultivar \`Kokinskaya Pozdnaya\`.

The difference between cultivars and treatments in total amount of runners was not significant.

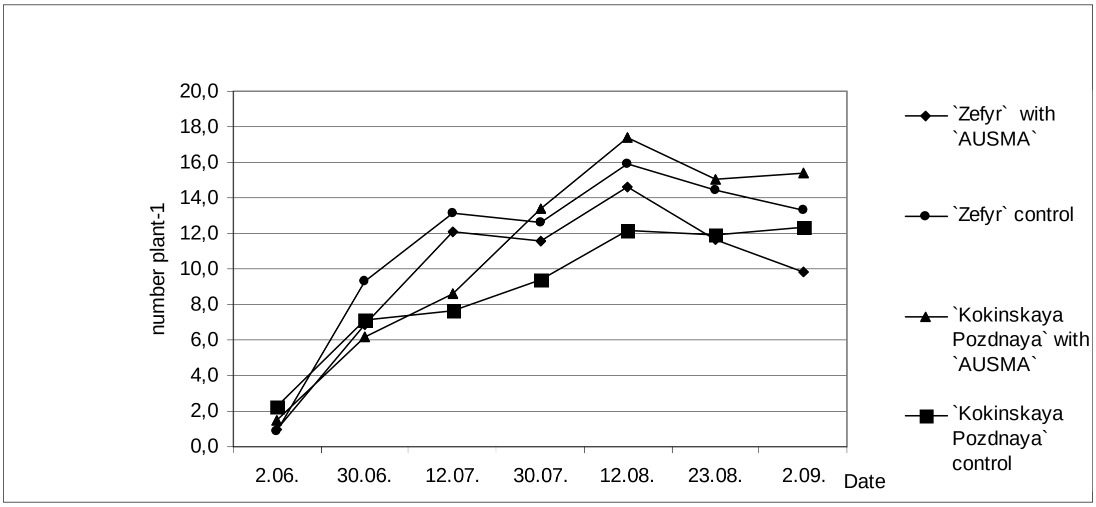

Figure 2. Influence of growth stimulator "Ausma" on runnering intensity of strawberry mother plants for two cultivars

Cultivar `Zefyr` produced significantly higher amount of runner plantlets suitable for rooting than `Kokinskaya Pozdnaya` (Figure 3). The highest amount of runner plantlets was obtained from cultivar `Zefyr` in the treatment without using of growth stimulator. `Kokinskaya Pozdnaya` had more runner plantlets in the treatment with growth stimulator than in control.

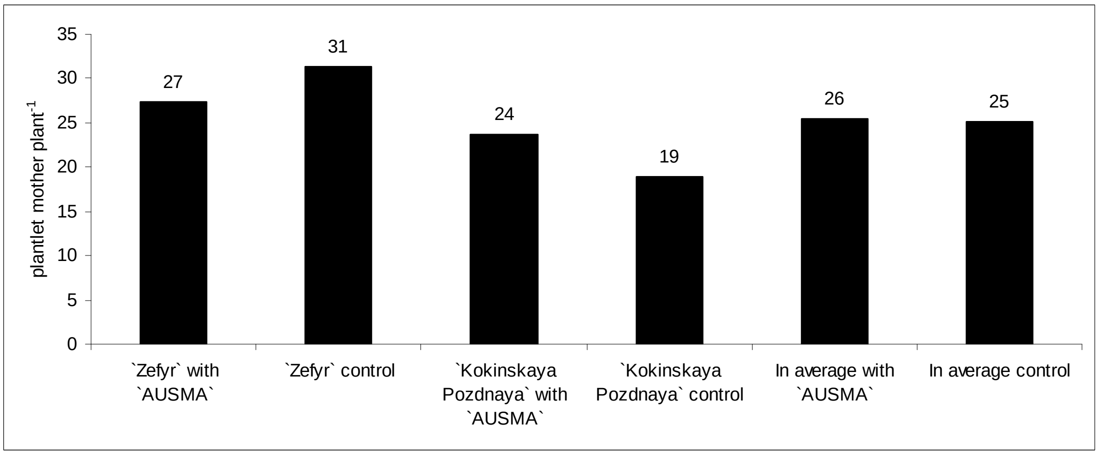

Figure 3. The total amount of runner plantlets suitable for rooting gotten from mother plants
$\gamma_{0.05\ (cultivar)} = 3.74$; $\gamma_{0.05\ (treatment)} = 3.74$; $\gamma_{0.05\ (separate\ means)} = 5.29$

In average of two cultivars significant difference in total amount of runner plantlets between using of growth stimulator and control was not stated.

Discussion

Studies conducted in many countries have confirmed a positive effect of growth regulators on plant growth, yield, fruit set and the quality of different crops (Bisen *et al.,* 1991; Greenberg *et al.,* 1992; Malaka and Bondok, 1997 and Phookan *et al.,* 1991). There are several studies on strawberries also. Different plant biochemical regulators in trials in Norway positively affected plant vegetative growth and yield of different strawberry varieties grown in the field (Rohloff *et al.,* 2002). Similar results were obtained by Thakur *et al.* (1991) and Masny *et al.* (2002). In our investigations natural growth stimulator ”Ausma“ showed different results depending on the applying technique in trials with runner plantlet rooting. It significantly did not influence strawberry plantlet rooting and development when was applied after potting only one time. However it succeeded plant development and significantly increased plant total weight, crown diameter and leaf number, if it was applied every 10 days. Any negative effect of growth stimulator on plant externally was not observed. Cultivars showed different intensity of plant development, but did not show a significant difference in reaction to the growth stimulator.

A significantly different reaction to the growth stimulator “Ausma” was observed between cultivars, when it was applied on mother plants of the Mo generation. The different reaction of strawberry cultivars to growth regulators is reported by Masny *et al.* (2002). In our trial applying of “Ausma” did not influence plant development and runnering for the cultivar `Zefyr` and even reduced the runnering intensity at the end of summer, while it significantly increased leaf growth and runnering for the cultivar `Kokinskaya Pozdnaya`. Mother plants of cultivar `Kokinskaya Pozdnaya` looked much healther in treatment with the use of growth the stimulator than in control.

Conclusions

The using of growth stimulator “Ausma” is perspective for strawberry plantlet producing and rooting. The application rate is one time every 10 days in 0.2 % concentration with watering is acceptable in strawberry plant rooting. More investigations are necessary on the application rate and the reaction of different cultivars in the use of “Ausma” for mother plants of Mo generation in runner plantlet production.

Acknowledgements

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References

1. Rohloff J., Hagen S.F. and Iversen T. (2002) The effect of plant biochemical regulators on strawberry production in field trials under drip irrigation management at 5 locations in Norway. Acta Horticulturae, 567, 463-466.
2. Webb R. (2004) The Ausma chronicals. In: Spring Bulletin, the National Sweet Pea Society, UK, 44-45.
3. Place I.D. (2004) Ausma sweet pea trials in Cumbria. In: Spring Bulletin, the National Sweet Pea Society, UK, 27.
4. Masny A., Zurawicz E. and Basak A. (2002) Super influence of ``Betoksan`` (BNOA) and other growth regulators on yield and quality in strawberry. Acta Horticulturae, 567, 467-470.
5. Bisen A.L., Saraf R.K. and Joshi G.C. (1991) Effect of growth regulators on growth and yield of garden pea (*Pisum sativum* L.) cv. G.C.322. Orissa Journal of Horticulture, 19, 57-63.
6. Greenberg J., Hertzano Y., and Eshel G. (1992) Effects of 2,4-D, etefon, and NAA on fruit size and yield of Star Ruby red grapefruit. In: Proceedings of the International Society of Citriculture. 7-th International Citrus Congress, Acireale, Italy, 8-13 March, 520-523.
7. Malaka S.A. and Bondok M.A. (1997) Effect of some growth regulators on fruit thinning, yield, fruit quality and endogenous hormone levels in Balady mandarins. Annals of Agricultural Science Cairo, 42, 217-229.
8. Phookan D.B., Shadeque A. and Baruah P.J. (1991) Effect of plant growth regulators on yield and quality of tomato. Vegetable Science, 18, 93-96.
9. Thakur A.S., Jindal K.K. and Sud A. (1991) Effect of growth substances on vegetative growth, yield and quality parameters in strawberry. Indian Journal of Horticulture, 48, 286-290.

CERTIFICATION SCHEME FOR FRUIT TREES IN GERMANY
AUGĻUKOKU SERTIFIKĀCIJAS SISTĒMA VĀCIJĀ

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Kopsavilkums

Pēc 2. pasaules kara Vācijā izveidoja atveseļota stādāmā materiāla audzēšanas sistēmu. Tika pierādīts, ka vīrusbrīvi stādi dos labāku ražu, ir izturīgāki pret stresa apstākļiem un pārstādīšanu salīdzinājumā ar inficētiem. No 1978.gada vīrsusbrīva stādāmā materiāla lietošana bija noteikta kā obligāta. Kopš 1992.gada, Vācijai pieņemot Eiropas likumdošanu, noteikumi tika atvieglotі. Rakstā sniegts Vācijas kokaudzētavu situācijas raksturojums un atveseļota stādāmā materiāla audzēšanas sistēmas izklāsts.

Abstract

After World War II a programme was started in Germany for the selection of healthy efficient mother trees for the further propagation of rootstocks and scion cultivars. It was shown that virus-free trees showed better compatibility, growth, yield, fruit quality than infected ones. Also they proved to be more tolerant towards stress and replant problems. Therefore it was ensured that mother plants became virus-free. From 1978 onwards the usage of virus-free planting material was compulsory. However, this decree was softened by a new European Union order in 1992 giving the growers free choice for certified plant material or material of minor health status. For quick marketing of new cultivars i.e. clonal material it allows to propagate planting material from mother plants of which the origin is known and which are true to cultivar, healthy and free of symptoms caused by pests and diseases. Therefore only visual tests have to be passed. With this procedure there is no guarantee for freedom of latent infections by economically important virus and phytoplasma diseases. In the paper statistics are given about number of nurseries and the annual fruit tree requirement of Germany. Procedures of mother plant selection, of virus elimination and certification are described. Finally data are given about the advantage of using virus-free planting material for sustaining yields and high fruit quality.

Introduction

With the intensification of fruit production after World War II, nurserymen and fruit farmers became aware that a main prerequisite for high yields of quality fruit would be the planting of healthy, efficient fruit trees. Since then a programme started for the careful selection of healthy, efficient mother trees for rootstock and scion cultivars, producing high yields of quality fruit. Moreover, viruses were eliminated by heat treatment and or meristematic tissue culture. From 1978 onwards the usage of virus-free planting material was made compulsory. In July 1992, the former, German legislation for the establishment of virus-free planting material was softened by a new European order giving the growers free choice for certified plant material or material of poor health status. However, for sustaining of competitive orchards only virus-free certified plants are recommended. The procedures of mother plant selection, of virus elimination and of certification are described in the paper.

Nurseries in Germany

In Germany nurseries for the propagation of rootstocks, fruit trees, ornamental shrubs and forest trees had a total area of 21,413 ha in 2004. Among others the area for rootstock propagation amounted to 7,535 ha, for fruit tree propagation 1,049 ha, ornamental shrubs 11,310 ha, forest trees 2,519 ha. There were 3,398 nurseries employing 32,500 people. In 2004, 29,506,000 fruit trees were produced indicating a slightly increasing trend for fruit tree production as compared with previous years. The imports of woody nursery plant material amounted to 140 million Euro and the export to 58 million Euro. The total production value for fruit trees was 1,3 billion Euro in 2004.

Selection of mother plants

Fruit tree cultivars mutate relatively easy, particularly in apple and pear, but also in *Prunus* species. Over a period of time, this may result in a decline of health yield efficiency and fruit quality. Similarly, this may also apply to rootstock cultivars. Therefore in Germany, especially in viticulture, selection work within the main cultivars has been practised for more than 50 years to obtain high quality mother plant material. So far the selection was bound to experimental plots, where records about growth, yield and fruit quality characteristics are taken regularly. An example is shown in Figure 1 for the selection of mother plants for the propagation of a vine cultivar.

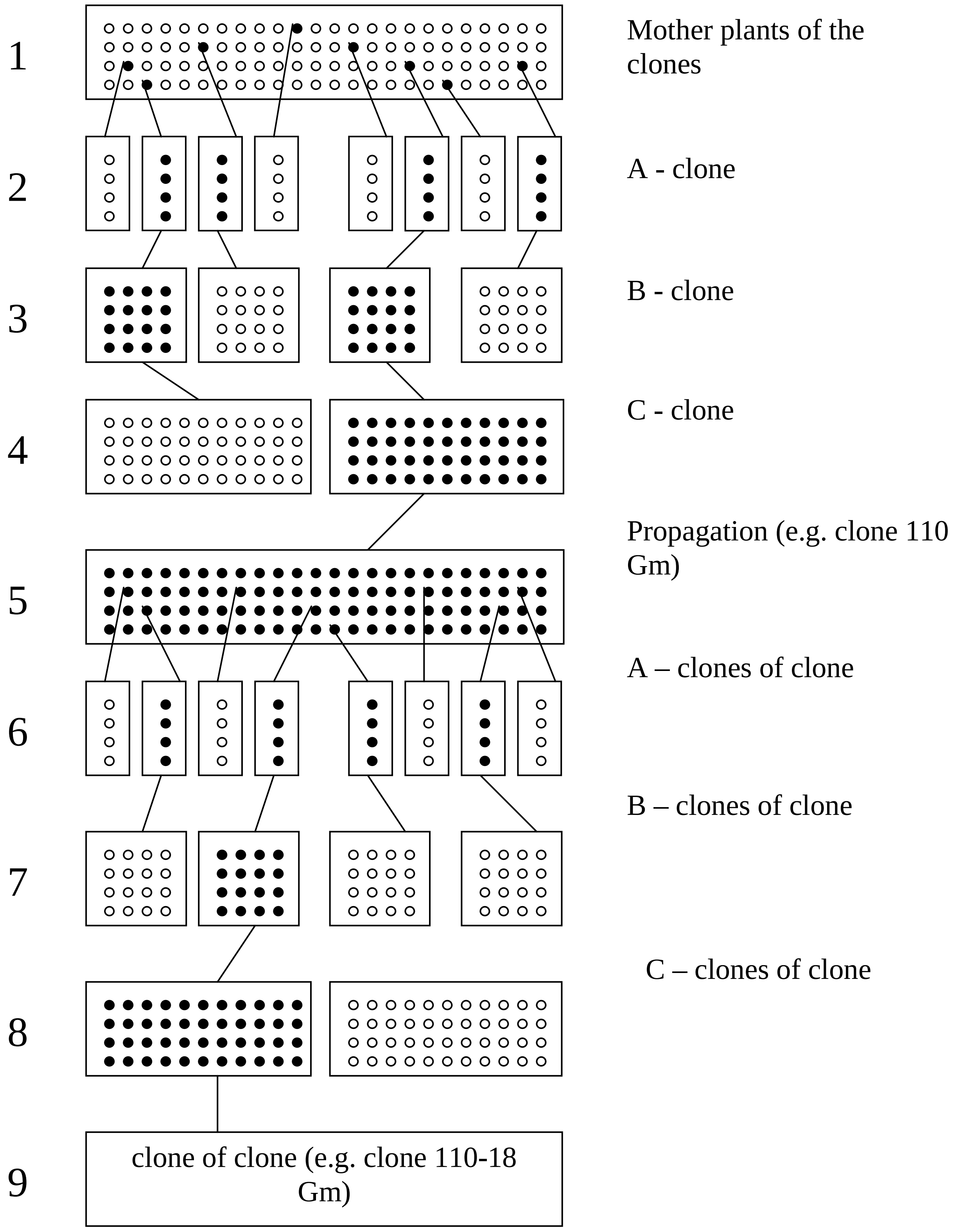

Figure 1. Scheme of the Geisenheim clonal selection: Selection of a clone out of a clone with proven good performance (e.g. 'Weiser Riesling' clone 110 Gm, clone 110-18 Gm, out of (5))

For the evaluation of the selected plant material the following characteristic are considered for the scion cultivars: growth parameters, yield and quality of fruits, health status, nutrient use efficiency, resistance or tolerance against diseases, pests and frost.

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For the selection of mother plants for the vegetative propagation of rootstocks the following characteristica are mainly considered: growth parameters, rooting ability, compatibility, adaption to the planting location.

P r o c e d u r e s o f v i r u s e l i m i n a t i o n

The selected so-called candidate scion or rootstock material is grafted on virus-free seedlings grown in containers filled with a sterilized substrate. For virus elimination, the candidate plants are kept in a growth chamber for about 6 weeks at temperatures of 38° C during the light and 36° C during the dark period. The shoot tip of the heat treated plants is either grafted onto a virus-free rootstock or propagated by tissue culture, the graft is protected with a plastic bag to maintain high humidity in the surrounding atmosphere.

The plant is grown then in a Saran-House to avoid any virus transfers by aphids. To be certain that the candidate mother plant is really free of virus, several HouseVirus tests are required during the following years (Fig. 2). These are done with indicator plants or with the help of Immun-Assay-Test. In addition also PCR-tests are used. The procedure to get high quality certified mother plants may last up to 5 – 12 years, depending on the number of tests required.

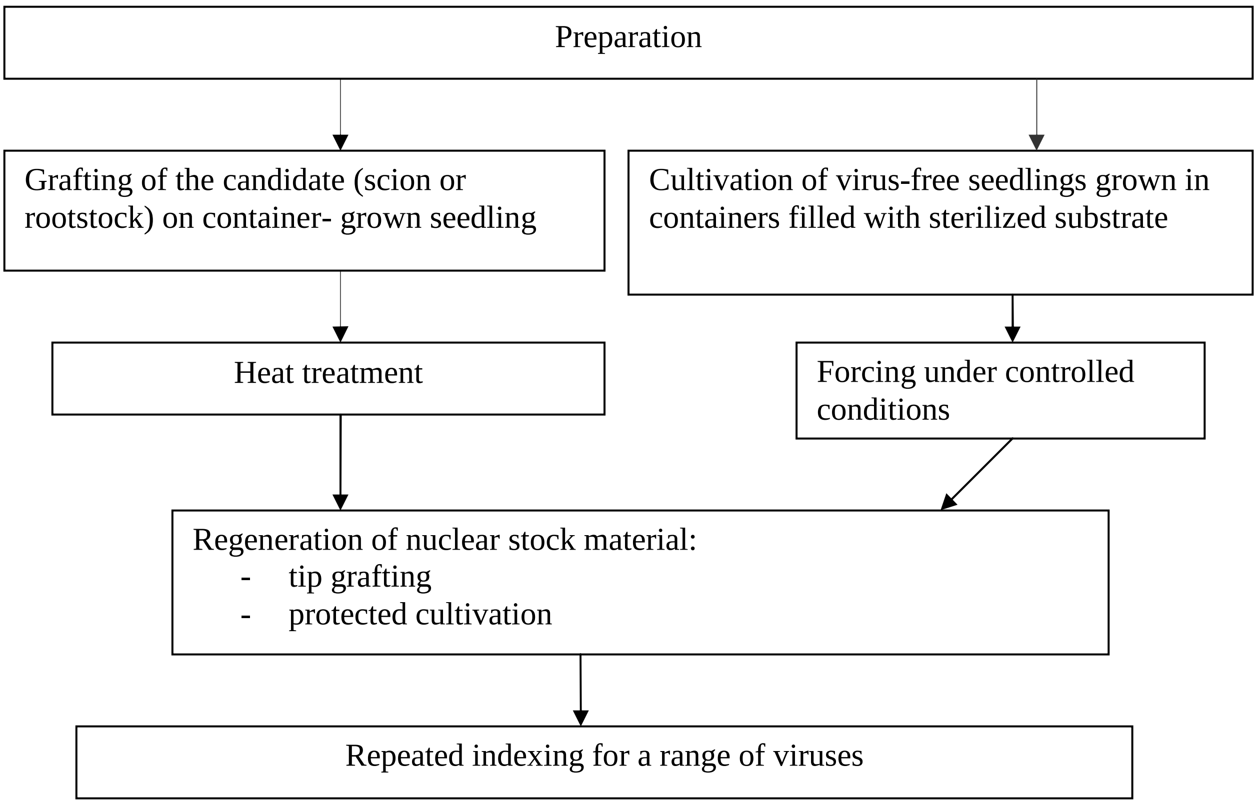


Figure 2. Procedure of virus elimination

The viruses in pome and stone fruit are named, which become eliminated by the above mentioned procedure, are named below:

- apple: Apple chlorotic leaf spot, Apple mosaic, Apple stem grooving, Apple stem pitting, spy epinasty and decline, platycarpa scalybark, Apple rubbery wood, Apple flat limb, Apple rough skin, Apple star crack, Apple proliferation; Pear and Quince: Apple chlorotic leaf spot, bark split, rough bark, Bark necrosis, rubbery wood, Pear vein yellows/red mottle, stem pitting, Pear stony pit, Quince sooty ringspot, Pear decline; Cherry: Apple chlorotic leaf spot, Apple mosaic, Prune dwarf, Prunus necrotic ring spot, Cherry leafroll, Little cherry, Raspberry ringspot, Rusty mottle, Cherry green ring mottle;
- plum: Apple chlorotic leaf spot, Plum bark split, Euopean plum line pattern, Apple mosaic, Prune dwarf, Prunus necrotic ring spot, Plum pox.

To speed up the establishment of virus-free mother plants soon after heat treatment, virus-free rootstocks are already budded with material from the pre-basis mother plants. These are planted into the field and become certified mother plants when it has been proved that they are virus free. The location for the certified virus-free mother plants should be free of nematodes and about 1 km away from the next orchard to reduce the danger of reinfection with virus.

Certification

There are two categories of fruit tree planting material on the market, providing the so-called “standard” as well as certified material.

CAC (Conformitas Agraria Communitatis) material

Standard material proved to be necessary for nurseries and farmers, who like to be quick on the market with promising new cultivars and interesting mutations of special main cultivars and don’t want to wait for years until it is certain that mother plants are virus-free.

Therefore, the European Union decree about the marketing of fruit tree planting material was less strict than the original German decree for the establishment of high quality virus-free fruit trees. It allows the marketing of plant material derived from mother trees of which the origin is well recorded. The material has to be true to cultivar. It has to be healthy according to visual tests and apparently free of the main viruses and pathogenes. The fruit trees ready for the market are certified with a white label indicating the country where produced, the species, cultivar, rootstock and the number of the plant passport according to the EU regulation.

Certified virus free fruit trees

If it has been proven that the pre-basis mother plants are really virus-free, then the descendants in the field can be certified if grown in soil free of nematodes and isolated about 1 km from the next orchard to reduce the danger of virus reinfection. However, these certified virus-free mother plants should not be used for longer than 8 years for the supply of scion wood. At annual intervals mother trees should be tested at random if they are still free of virus and other pathogens (Fig. 3).

If nurseries establish young fruit trees using rootstocks and scions from certified virus-free mother plants, then the young trees can be labelled for the market as certified virus-free. The red label has a code, name of species, cultivar and rootstock. The label also serves as a plant passport when treated within EG countries.

Apart from the fact that the nursery plants are true to cultivar, healthy and virus-free they should have a high standard in regard to growth, feathering and root the system. General demands for nursery plants:

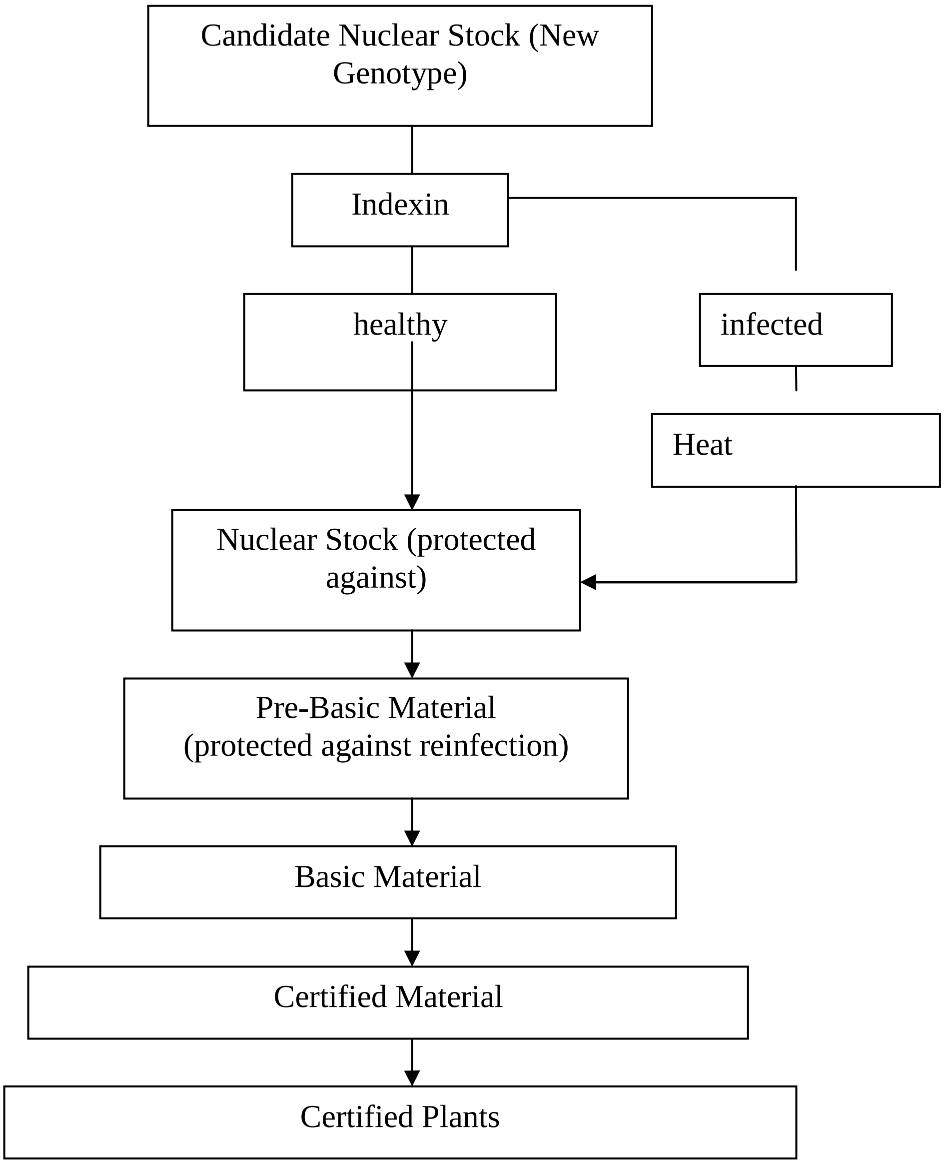
- legal regulations (e.g. EU guidelines) have to be fulfilled;
- fruit trees propagated by *in vitro* methods have to agree with the demands specified for fruit trees propagated by conventional methods.

Demands for apple trees:

- apple bushes have to be grafted on rootstocks propagated vegetatively.

Demands for knipp trees:

The one-year-old tree must have been cut back to a minimum height of 60 cm above soil level. Minimum number of branches: 5, equally arranged, homogenous in size, minimum length: 20 cm. Central leader with minimum length of 50 cm and minimum diameter of 9 mm.



Figuure 3. European Union certification scheme

The Department of Agriculture approves the application to multiply virus-free fruit tree material and controls the nurseries.

Obligations of fruit tree nurseries

The fruit tree nurseries have to regularly control the status of trees to investigate possible pest and disease infections. They have to keep records about the type and numbers of trees grown and traded and about infections and pests as well as spray applications. The nursery producing certified fruit trees has to be registered at the Division of Plant Protection of the Department of Agriculture. Nurseries propagating certified trees are inspected at intervals by members of the Division of Plant Protection.

The advantage of virus free planting material

There are many examples, indicating that virus-free planting material even in comparison with plants only free of main virus are better in growth, feathering, and rooting. They therefore more easily overcome difficulties due to replanting problems, drought and other stress factors (Tab. 1).

Table 1. An impact of health status on the performance of replanted 'Cox Orange' until the 7th year

Parameter	Virus-free	Virus-tested	Infected
Stem diameter (m)	5.6	5.5	4.3*
Accumulated yield (kg/tree)	64.6	44.3*	29.2*
Fruit weight (g/fruit)	133	126	110*

*LSD, p=0.05

They produce more regular, increased yields of high fruit quality, may be also due to improved water and nutrient use efficiency (Table 2).

Table 2.Interaction between health status and planting density as affecting yield and fruit size replanted 'Jonagold' on M.9 until the 6th year

	1700 trees/ha		2600 trees/ha	
Parameter	Virus-free	Virus-tested	Virus-free	Virus-tested
Accumulated yield (t/ha)	100.5	71.0	111.0	100.0
Fruit weight (kg/fruit)	205	188	197	176

Virus-free fruit trees are superior in: compatibility, growth and branching; yield and fruit quality; tolerance towards different stress factors including replanting problems; sustaining production, duration of the orchard.

However, it also has been reported that such certified virus-free trees may show vigorous growth with delay of crop production. If the mother plants are cut back too strong for obtaining scions, then it may happen that from some buds of the new appearing shoot develop growth of juvenile character.

Conclusions

Careful selection within cultivars for health, high yields of quality fruit and virus elimination is prerequisite to obtain mother plants providing efficient healthy and planting material for competitive new orchards. Unfortunately this is not always recognized and sometimes superficially practised. This is so, because new European regulations allow trading with only visually controlled CAC plants. The aim of all European countries should be that fruit tree nurseries provide enough certified virus free plants for all plantings to come.

EVALUATION OF APPLE ROOTSTOCK PURE 1
ĀBEĻU POTCELMA PURE 1 IZVĒRTĒJUMS

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Kopsavilkums

Sarkanlapaino ābeļu klona potcelmu Pure 1 ir atlasījis A. Bite no B.9 brīvas apputes sējeņiem 1971. gadā Pūres Dārzkopības izmēģinājumu stacijā. Pūre 1 ir līdzīgs potcelmam B.9, bet tam ir augstāks pavairošanas koeficients klona potcelmu mātesaugu stādījumā. Rakstā analizēti rezultāti, kuri iegūti laika posmā no 1997. līdz 2004. gadam no dārza, kurš stādīts 1996. gadā. Izmēģinājumā iekļautas šķirnes \`Spartan\`, \`Belorusskoje Maļinovoje\`, \`Sinap Orlovskij\` un \`Kovalenkovskoje\`. Veģetatīvā auguma rādītāji kokiem uz potcelma Pūre 1 bija līdzīgi kā uz potcelmiem B.9 un M.9. Pure 1 pēc potcelma ietekmes uz ziedpumpuru veidošanos ir pieskaitāms pie augstražīgiem potcelmiem. Pure 1 var rekomendēt kā viegli pavairojamu, un augstražīgu pundurpotcelmu.

Abstract

A. Bite selects the redleaved apple clonal rootstock Pure 1 from the seedling of open pollination of B.9 in 1971 at the Pure Horticultural Research Station. Rootstock Pure 1 is similar to B.9, nevertheless Pure 1 has a higher rate of propagation in the mother-tree plantation.

Data obtained during 1997 – 2004 years from the orchards planted in 1996 and 2000 have been analysed. Cultivars \`Spartan\`, \`Belorusskoye Malinovoye\`, \`Sinap Orlovskiy\` and \`Kovalenkovskoye\` were used in the investigation. The Parameters of the vegetative growth of trees on Pure 1 were similar to trees grown on B.9 and M.9. Rootstock Pure 1 is referable to the group of high-yielding rootstocks according to the influence of the rootstock on the development of floral buds.

Overall rootstock Pure 1 is recommended as easily propagated, dwarfing and high-yielding rootstock.

Key words*:* clonal rootstock, horticulture, vegetative growth, generative development, productivity

Introduction

The development of horticulture in Latvia has been increasing in recent years. Apples have the biggest consumption demand of all fruits in Latvia. The total acreage of apple commercial orchards is about 4 300 ha. Dwarf trees (1200 to 1500 trees per ha) or semi dwarf trees (600 to 800 trees per ha) are mostly used in the establishing of new plantations. Selection of appropriate rootstock is one of the main questions during the establishment of an orchard. The rootstocks B.396, Pure 1, B.9, M.26 and MM.106, B.118 currently are most often used in new plantations.

Long-term investigations on clonal rootstocks have been carried on in Latvia. The first investigation in the Pūre Horticultural Research Station was carried at in 1937. A. Bite started the investigations on the clonal rootstocks in 1960-ies. Some selections are derived (Lepsis, 1999). Since 1996, the rootstock evaluations in intensive orchards are carried on at the Pure Horticultural Research Station. Selections of Michurinsk University (B series) are predominant in these investigations. Several international scientific projects on the research of rootstock studies have been implemented during the previous five years with the participation of scientific institutions of Latvia, Lithuania, Estonia, Byelorussia and Poland. The aim of these projects is to evaluate the rootstocks in different climatic and soil conditions (Bite *at al.* 2004). In the frame of international projects the evaluation of rootstocks of P series is started. In 1987 the investigations on apple clonal rootstocks was carried on and started at the Dobele Horticultural Research and Breeding Station. Rootstocks of West Europe, USA and Soviet Union origin were investigated (M.9, M.26, MM.106, CG.65, Mark, C.6, CG.13, CG.10, B.9, B.396, B.491, B.118, et.c.) (Leibuss, 1998).

Materials and Methods

Rootstock Pure 1 has been selected by A. Bite from the seedlings of open pollination of the Budagovskiy Paradise Apple (B.9) in 1971 (Bite, 1999). In comparison with B.9, rootstock Pure 1 showed better propagation rate and improved winter hardiness (Bite and Lepsis, 2004).

Rootstock Pure 1 along with other clonal rootstocks was included in two investigations in the orchard for evaluation (Tab. 1). In the investigation established in1996 beside rootstocks different planting systems with tree density from 1250 to 3075 trees per ha were evaluated. Trees were formed in different crown forms: free growing spatial crown, slender spindles, French axis, flattened spindles and North-Holland spindles. In the investigation established in 2000 a planting density of 4 x 1.5 m (1665 tree per ha) was used, trees formed as slender spindles. Tree vegetative growth was characterised by trunk cross section area (TCSA) which was calculated from the trunk diameter, tree height and crown volume which was calculated for the cone figure by using tree height and crown diameter in two directions. Generative development (or tree productivity) was evaluated by the total number of inflorescences per tree and the number of inflorescences per crown volume unit (crown volume registered in the previous autumn). Both investigations were established in four replications. Analysis of variance and Duncan criteria were used for statistical analyse.

Table 1. Rootstock and cultivars used in the investigations

Planting years	Rootstocks	Varieties
1996	B.9	\`Spartan\`
	Pūre 1	\`Belorusskoye Malinovoye\`
2000	B.146, B.257, B.366	\`Belorusskoye Malinovoye\`
	B.396, B.476, B.491	\`Sinap Orlovskiy\`
	B.9, Bulboga	\`Kovalenkovskoye\`
	M.9, Pūre 1	

The trials were located at the Pure Horticultural Research Station (HRS). It is situated at 57°02\` N and 22°52\` E, 50 m above sea level, the average temperature per year is +7.5 °C, precipitation sum is 600 – 700 mm, precipitation in the vegetation period (May – October) is about 300 – 350 mm. Unfavourable weather conditions have been observed during the last five years. It had a significant influence on the apple yield. Severe spring frosts during blossom time were observed in the years 2000 (-2…-3 °C), 2002 (-1…-3 °C) and 2004 (-6…-8 °C). The base of the floral bud significantly suffered in the winter of 2000/2001, when the minimal temperature reached -28…-30 °C at the beginning of February and -12…-14 °C at the end of March. Very severe hail damaged practically all the yield in June of 2003.

Results and Discussion

Vegetative growth.

In the investigation established in 1996, significant differences in the tree vegetative growth were not observed for the first five years. Starting with the 6th year smaller crown volume was observed for cv. \`Spartan\` on the rootstock Pure 1. Starting with the 7th year also the trunk cross section area (TCSA) on Pūre 1 rootstock was significantly smaller than on B.9. For cv. \`Belorusskoye Malinovoye\` significant differences in tree vegetative growth between different rootstocks were not stated (Tab. 2).

In the investigation established in 2000, at the 5th year after planting TCSA, tree height and crown volume for cv. \`Belorusskoye Maļinovoye\` were similar on rootstocks: Pure 1, B.9, B.257, B.366, B.396, B.476, B.491, M.9. For cv. \`Sinap Orlovskiy\` rootstock Pure 1 had similar influence as B.9, B.257, B.366, B.476, B.491, M.9, but on the rootstock B.396 TCSA was significantly greater than on Pure 1. Tree vegetative growth of cv. \`Kovalenkovskoye\` on rootstock Pure 1 was similar to trees grafted on B.9, B.257, B.366, B.396, B.491, M.9. The most vigorous trees for all three cultivars were observed on the rootstocks B.146 and Bulboga.

Rootstock Pure 1 was determined as semi-dwarfing at the beginning of the investigation (Bite 1999), but obtained results show that it is dwarfing, similar to B.9 and M.9. Lithuanian colleagues drew similar conclusions.

They also group the Pure 1 rootstock in the same group with M.9, B.396, York 9, P.60, B.9 and P 2 (Bite *et al.* 2006).

Table 2. Vegetative growth, investigation planted in 1996, data of 2004

Rootstock	Trunk cross section area, cm^2	Tree height, m	Crown volume, m^3
\`Spartan\`			
B.9	17.6 b[1)]	2.7	2.2 b
Pūre 1	15.1 a	2.6	1.8 a
P value	*0.033*	*0.346*	*0.025*
\`Belorusskoye Maļinovoye\`			
B.9	19.7	2.8	1.9
Pūre 1	19.2	2.7	1.7
P value	*0.727*	*0.588*	*0.311*

[1)] values marked by different letters have significant difference (criteria of Duncan , α=0,05)

G e n e r a t i v e   d e v e l o p m e n t .

In the investigation established in 1996, the total number of inflorescences per tree and number of inflorescence per crown volume determined tree potential yield. Significant differences for these parameters for cv. \`Spartan\` and \`Belorusskoye Malinovoye\` on rootstocks B.9 and Pure 1 were observed only in a few years. At the 6th year after planting for cv. \`Spartan\` on rootstock Pure 1 there was a significantly higher number of inflorescence per crown volume unit (on Pure 1 it was 124 inflorescences per m^{-3}, but on B.9 it was 104). Cv. \`Belorusskoye Malinovoye\` at the 4th year after planting had higher amount of inflorescence per tree and per m^3 on rootstock B.9 (on Pure 1 it had 30 inflorescences per tree and 71 inflorescences m^{-3}, but on B.9 it had 39 inflorescences per tree and 100 inflorescences m^{-3}). At the 6th year after planting trees on rootstock B.9 had the highest number of inflorescences per tree (on Pure 1 it had 95 inflorescences per tree, but on B.9 it had 106). In this year significant differences between trees on both rootstocks were not stated after number of inflorescences per crown volume unit (Pure 1 had 238 inflorescences m^{-3}, B.9 had 264).

Yield parameters were significantly influenced by adverse weather conditions during last five years. Cumulative yield from trees of cv. \`Spartan\` on rootstock B.9 from 1998 to 2004 was 3.9 kg per tree and on rootstock Pure 1 it was 4.3 kg per tree. For cv. \`Beloeusskoye Malinovoye\` it was correspondingly 8.9 and 8.7 kg per tree. Significant differences were not stated for these cultivars between both rootstocks. Obtained yield was very low, it did not characterise rootstocks in general, just showed that influence of both rootstocks on the tree yield is similar.

In the investigation established in 2000, the number of inflorescences of cv. \`Kovalenkovskoye per crown volume unit significantly did not differ between rootstocks at the 4th and 5th years after planting (Fig.1).

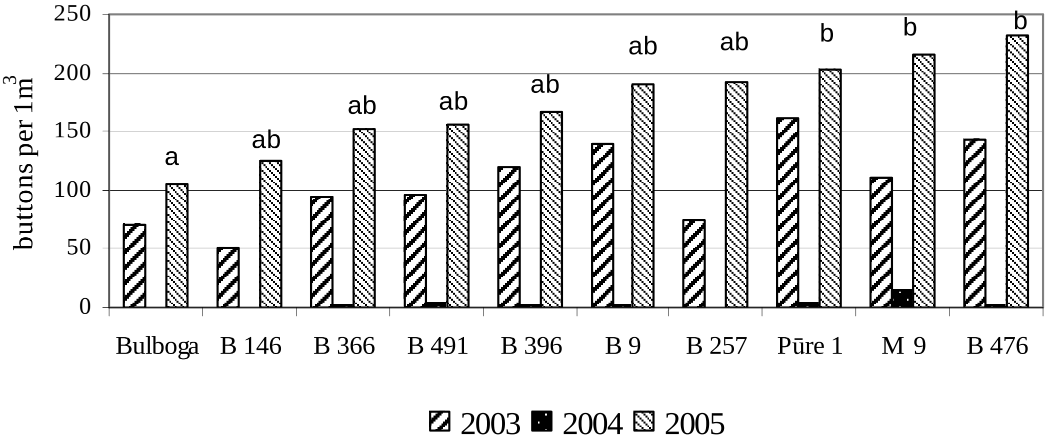

Figure 1. Number of flower button per tree crown volume, cultivar \`Kovalenkovskoye\` (planting year 2000)

Significant influence of rootstock was observed at the 6th year after planting. There the least amount of inflorescences per crown volume unit was observed on the rootstock Bulboga, significantly more inflorescences were observed on treess grafted on B.476, M.9 and Pure 1.

For cv. `Belorusskoye Malinovoye`, the number of inflorescences per crown volume unit was showed significantly differences between investigated rootstocks in the 4th year after planting (Fig. 2). The least number was for trees on B.146, which significantly differed from B.9, Pure 1 and B.366. In the 5th and 6th year after planting significant differences were not stated.

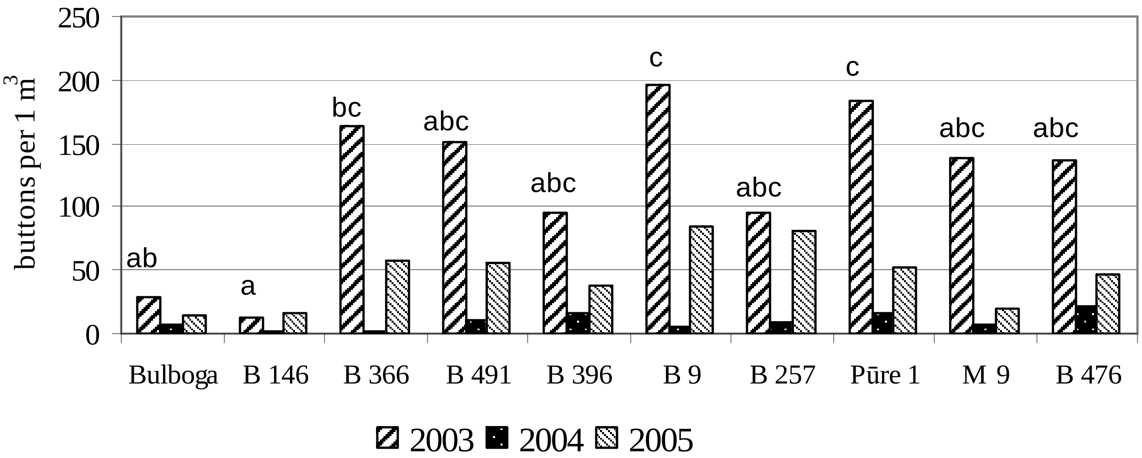

Figure 2. Number of flower button per tree crown volume, cultivar `Belorusskoye Malinovoye` (planting year 2000)

Cv. `Sinap Orlovskiy` developed less floral buds, than both other investigated cultivars. Significant differences between rootstocks were stated only at the 6th year after plating (Fig. 3). The Least floral buds amount per crown volume was observed on Bulboga rootstock. Significantly more floral buds were developed on the trees grafted on rootstocks M.9, B.476 and B.366.

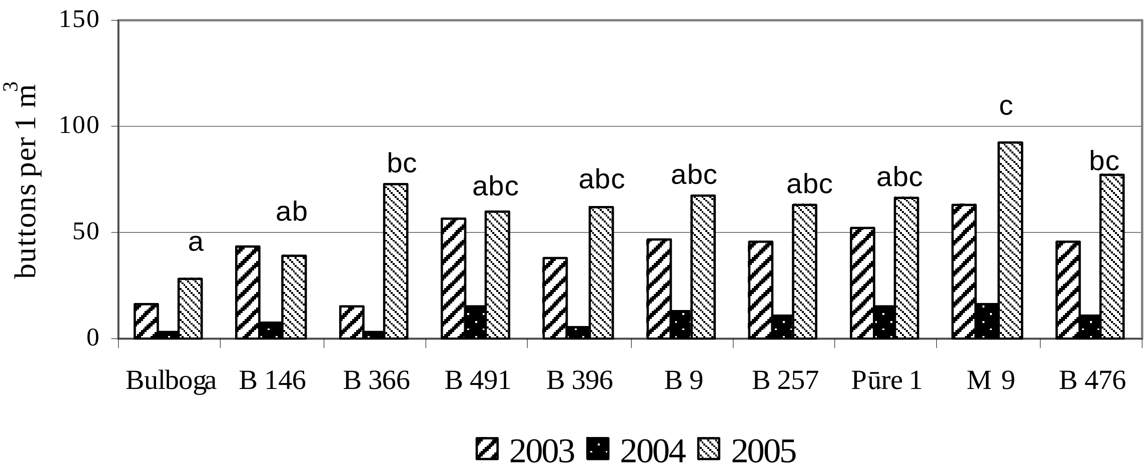

Figure 3. Number of flower button per tree crown volume, cultivar `Sinap Orlovskiy` (planting year 2000)

The potential yield from the trees grafted on rootstock Pure 1 was higher or significantly did not differ from other rootstocks according to the results of the investigations.

In the investigations of Lithuanian scientists it was noted that trees on the rootstock Pure 1 yield more, but it is connected with the smallest average weight of fruits. Also earlier ripening of fruits is observed on the fruits grafted on Pure 1. (Kviklienė and Kviklys, 2006). Decreasing of the fruit mass is observed also in other investigations for high yielding rootstocks. Grafting of big sized fruit cultivars is one of the solutions (Dziuban *at al.*, 2004).

In 2004, small amount of inflorescences developed on the trees of all cultivars. It was caused by very severe hail at the end of July of 2003 – beginning of floral bud differentiation, when tree foliage and trunk skin were damaged. The shock caused by hail diminished floral bud differentiation. Yields were too insignificant to evaluate rootstock influence on the yield due to meteorological conditions.

Conclusions

The vegetative growth of trees grafted on Pure 1 rootstock is similar to trees grafted on B.9 and M.9.

According to the influence of rootstock on the formation of inflorescence, rootstock Pūre 1 is referable to the group of high-yielding rootstocks.

In general rootstock Pūre 1 is recommended for wide using as easily propagated, dwarfing, high-yielding rootstock.

References

1. Bite A. (1999) Pure 1: A new semi dwarf apple rootstock. In: Fruit growing today and tomorrow. Collection of Scientific Articles. Dobele, 131- 135.
2. Bite A., Kviklys D., Univer T. and Lukut T. (2004) The beginning of the project "Baltic fruit rootstock studies" In: Moreno Sanchez M.A. and Webster A.D. (eds) Rootstocks for Deciduous Fruit Tree Species// 1 international symposium on Rootstocks for Deciduous Fruit Tree Species. Acta Horticulturae, 658 (1), 437- 440.
3. Bite A. and Lepsis J. (2004) The results of extended duration testing of apple rootstocks in Latvia. In: Janick J KviklienėN., Kviklys D. (2006) Rootstock effect on maturity and quality of 'Auksis' apples // Sodininkystė ir daržininkystė, 25(3) (in press)for Deciduous Fruit Tree Species. Acta Horticulturae, 658 (1), 115-118.
4. Bite A., Haak E., Kviklienė N., Kviklys D., Lepsis J. and Lukut T. (2006). Baltic fruit rootstock studies: evaluation of 12 rootstocks for apple cultivar 'Auksis' // Sodininkystė ir daržininkystė, 25(3) (in press).
5. Dziuban R., Jablonski K. and Sadowski A. (2004) Growth and cropping of three apple cultivars on different rootstoks over a 7-year period. In: Moreno Sanchez M.A. and Webster A.D. (eds) Rootstocks for Deciduous Fruit Tree Species// 1 international symposium on Rootstocks for Deciduous Fruit Tree Species. ActaHorticulturae, 658 (1), 437-440.
6. Kviklienė N. and Kviklys D. (2006). Rootstock effect on maturity and quality of 'Auksis' apples // Sodininkystė ir daržininkystė, 25(3**) (**in press)
7. Lepsis J. (1999) History of the investigations of apple clonal rootstocks in Latvia. In: Fruit growing today and tomorrow. Collection of Scentific Articles. Dobele. 136 -140.
8. Leibus M. (1998) Influence of different rootstocks on the growing and development of cv. \`Auksis\` in Latvia conditions. Conferene of doctoral students of LUA "Vide cilvēkam, cilvēks videi", Jelgava. 17.- 22.

GROWTH OF ROOTSTOCKS FOR PEARS AND PEAR CULTIVARS BUDDED ON THEM – IN THE NURSERY
BUMBIERU POTCELMU UN ŠĶIRŅU AUGŠANAS IZVĒRTĒJUMS KOKAUDZĒTAVĀ

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Kopsavilkums

2002. gada pavasarī Varšavā tika ierīkots izmēģinājums ar sešiem potcelmiem: Kaukāza bumbieres sēklaudži (Cps), OH×F 333, 'Pyrodwarf' un trīs cidonijas - S_1, MA un MC. Uz tiem acoja šķirnes 'Conference' un 'Erika'. Stādus kokaudzētavā audzēja 3 gadus. Potcelmu augumu novērtēja pēc potcelma un potes diametra, dzinumu garuma un sakņu masas. Lielākā sakņu masa un stumbra diametrs bija uz Cps un 'Pyrodwarf' potcelmiem. Visiem kokiem uz cidoniju potcelmiem bija mazāks diametrs. Šķirnei 'Conference' bija vienādi spēcīgi koki gan uz OH×F 333, gan cidonijām. Šķirnei 'Erika' spēcīgāka auguma koki bija uz bumbieru potcelmiem, nekā uz cidonijām. Kopumā šķirnes 'Erika' kokiem bija garāki dzinumi, nekā šķirnei 'Conference`.

Abstract

In the spring at 2002 six rootstock types were planted in Warsaw-Wilanów, Central Poland: three originated from pear – Caucasian pear seedling (Cps), OH×F 333, 'Pyrodwarf' and three quinces – S_1, MA and MC. They were budded with 'Conference' and 'Erika' pear cultivars. The trees were grown in a 3-year nursery cycle. The vigour of rootstocks was assessed by the rootstock and scion diameters shoot length and root mass. Root mass was greater when Cps or 'Pyrodwarf' was used. The most vigorous (as indicated by stem diameter) were Cps and 'Pyrodwarf', followed by OH×F 333; all quinces had smaller diameters. A similar growth pattern was noted in 'Conference' maidens, but no difference was found between OH×F 333 and quinces. 'Erika' maidens had larger diameter when budded on pear rootstocks than when budded on quince MA or S_1. In two-year-old 'Conference', stem diameter was larger on pear rootstocks than on quince S_1 or MC. 'Erika' two-year-old trees on Quince MA had smaller stem diameter than on pear rootstocks. The largest total shoot length was in Cps and in pears budded on it. The effect of 'Pyrodwarf' on shoot growth was similar to that of Cps. In general, 'Erika' maidens had a larger total shoot length than 'Conference'.

Key words: rootstock, pear, quince, maiden-trees, two-year-old-trees, knip-boom

Introduction

Pear is becoming an important fruit crop in Poland. The main factor limiting development of intensive pear orchards in Central Europe has been a lack of winter hardy, low-vigour rootstocks. Quince MC, the most suitable for intensive orchards in a maritime climate of Western Europe (Wertheim, 1998), was found the least winter hardy when tested in Poland (Iwaniszyniec and Hołubowicz, 1995). In the last decades few new rootstocks from *Pyrus genera* were selected (Lombard and Westwood, 1987; Jacob, 1998). Some of them provide a low vigour (Jacob, 1998 and Wertheim and Balkhoven-Baart, 1997). They can be a good solution for pear rootstock problems in our climatic conditions. A very important factor affecting the success of intensive orchards is the quality and the type of planting stock (Sadowski *et al*., 2000 and Sadowski *et al*., in print).

The objective (aim) of this study was to assess the performance of widely used and new pear rootstocks, in the traditional, two-year nursery cycle, as well as in the tree-year nursery cycle – resulting in the production of two-year-old trees with renewed leader (Dutch knip-boom).

Materials and Methods

The trial was carried out at the Wilanów Experimental Station of the Department of Pomology and Basic Natural Sciences in Horticulture, Warsaw Agricultural University, situated in Central Poland, in the post-glacial valley of Vistula River. Six types of rootstocks, Caucasian pear seedlings (Cps), OH×F 333, 'Pyrodwarf', Quince S_1, Quince MA and Quince MC, were planted on a silty loam alluvial soil in spring 2002. Rootstocks were planted 30 cm in row and 75 cm between rows. The trial was designed in randomised blocks, with 5 replications and 25 plants per each rootstock/cultivar combination.

In August rootstocks were chip-budded with 'Conference' and 'Erika' pear cultivars, at the height of 10 cm. After the second growing season the scion cultivars were headed back at the height of 75 cm and all laterals present below were removed). At the end of May the renewed leaders were sprayed with the branching promoter, Arbolin 36 SL (BA and GA_3), at the concentration of 25 $cm^3 \cdot dm^{-3}$ and the crowns were formed of sylleptic shoots (“knip-boom” method).

After the first and second growing season rootstock diameter was measured at 5 cm above the ground. After the second and third growing season the stem diameter of the scion cultivar was measured, at 10 cm above the union. The root mass of two randomly selected plants from each plot was weighed after the first and second growing season. The length of leader and of all lateral shoots was recorded after every growing season.

The data were analysed using analysis of variance. For separation of means the Newman-Keuls test was applied, at α=0,05.

Results and Discussion

After the first and second growing season the largest stem diameters were recorded for Caucasian pear seedlings (Cps) and 'Pyrodwarf' (Table 1) whereas OH×F 333 had intermediate and all quinces the smallest diameters. No cultivar effect on the rootstock diameter after second growing season was recorded. A growth pattern similar to that of rootstocks was noted for scion diameter of 'Conference' maidens, no difference was found between OH×F 333 and quinces. 'Erika' maidens had a larger scion diameter when budded on any pear rootstock than when budded on quince MA or S_1. The stem diameter of two-year-old 'Conference' was larger on pear rootstocks than on quince S_1 or MC. Two-year-old 'Erika' trees on Quince MA had a smaller stem diameter than on any pear rootstock.

Table 1. Diameter of different plant parts as influenced by rootstock, mm

Plant part and tree age or cultivar	Cps	OH×F 333	'Pyrodwarf'	Quince S_1	Quince MA	Quince MC
Rootstock after the 1st growing season	16.8 c*	14.0 b	16.9 c	12.7 a	13.0 a	12.1 a
Rootstock after the 2nd growing season	24.4 c	20.2 b	24.3 c	18.2 a	18.4 a	18.2 a
1-year-old 'Conference' scion	17.1 b	14.2 a	16.1 b	13.8 a	14.6 a	13.2 a
1 year old 'Erika' scion	15.7 bc	14.8 bc	16.4 c	12.8 a	12.0 a	14.4 b
2 year old 'Conference' scion	22.9 b	20.8 b	20.8 b	17.5 a	19.1 ab	17.6 a
2 year old 'Erika' scion	21.1 b	20.1 b	21.5 b	18.1 ab	17.0 a	19.9b

*- values in one row followed by the same letter(s) do not differ significantly, at α=0,05.

After the first growing season the root mass of Caucasian pear seedlings or of 'Pyrodwarf' was greater than the root mass of OH×F 333 or of any quince (Table 2). After the second growing season a similar regularity was recorded, with an exception those trees on Cps had significantly heavier roots than those on 'Pyrodwarf'.

Table 2. Root mass depending on rootstock, g

Time of record	Cps	OH×F 333	'Pyrodwarf'	Quince S_1	Quince MA	Quince MC
after the 1st growing season	49.4 b*	29.9 a	46.9 b	23.6 a	23.6 a	24.5 a
after the 2nd growing season	263 c*	119 a	187 b	117 a	117 a	115 a

*- values in one row followed by the same letter(s) do not differ significantly, at α=0,05.

The highest vigour, as estimated by the total shoot length, was shown by Cps and by pears budded on it (Table 3). The effect of 'Pyrodwarf' on shoot growth in the first and second growing season was similar to that of Cps.

In general, 'Erika' maidens had a larger total shoot length than 'Conference'.

Table 3. Total shoot length depending on rootstock, cm

Kind of plant	pps	OH×F 333	'Pyrodwarf'	Quince S_1	Quince MA	Quince MC
rootstock	771 c*	361 a	907 c	477 ab	598 b	531 ab
maiden tree (mean of two scion cvs)	519 c	362 b	505 c	243 a	258 a	268 a
2 year old 'Conference' scion	722 c	629 b	572 ab	466 a	570 ab	483 a
2 year old 'Erika' scion	716 c	589 ab	632 bc	505 ab	485 a	602 b

*- values in one row followed by the same letter(s) do not differ significantly, at α=0,05.

In the world pomological literature information is missing concerning the performance of pear rootstocks in the nursery, even in the traditional two-year nursery cycle.

In the Latvian trial (Lepsis *et al*., 2004) 'Suvenirs' pear on OH×F 333 was much more vigorous (vigour expressed as TCSA) than on 'Pyrodwarf' or on Quince MA and MC. Our results show that maidens of 'Conference' on OH×F 333 were less vigorous (vigour expressed as diameter of maidens) than on 'Pyrodwarf' and similar to that on quince rootstocks. Maidens of 'Erika' were equal in vigour on all rootstocks originated from *Pyrus genera* and on OH×F 333 were similar to those on Quince MC. In an older work at East Malling, England, Parry (1981) showed that young pear trees on Quince MC were growing in the orchard at a similar rate as those on Quince MA.

In general, pear maiden trees grown in Central Poland were taller than maidens grown in Baltic countries (Kviklys, 2000; Lepsis *et al*. 2004).

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References

1. Iwaniszyniec P. and Hołubowicz T. (1995) Wytrzymałość na mróz jednorocznych pędów trzech typów pigwy (*Cydonia oblonga* Mill.). Prace z Zakresu Nauk Roln. PTPN (Poznań) 79, 179-185.
2. Jacob H.B. (1998) Pyrodwarf, a new clonal rootstock for high-density pear orchards. Acta Hort., 475, 169-177.
3. Kviklys D. (2000) Paprastojo svarainio (*Cydonia oblonga* Mill.) sėkliniai poskiepiai kriaušėms. Sodininkysté ir Daržininkysté, Lietuvos Sodininkystés ir Daržininkystés Instituto ir Lietuvos Žemés Űkio Universiteto Mokslo Darbai / Scientific Works of the Lithuanian Institute of Horticulture and Lithuanian University of Agriculture, 19 (2), 23-25.
4. Lepsis J., Drudze I. and Dekens U. (2004) The evaluation of different plum and pear rootstocks in the nursery. Acta Hort., 658, 167-172.
5. Lombard, P. B. and Westwood. M. N. (1987) Pear rootstocks. In: R.C. Rom and R.F. Carlson (eds.), Rootstock for fruit crops. Wiley-Interscience Publication, John Wiley and Sons, New York, USA, 145-183.
6. Parry M.S. (1981) Trials of dwarfing quince rootstocks with 'Comice' and 'Conference' pears. J. Hort. Sci., 56 (2), 139-143.
7. Sadowski A., Mackiewicz M. and Dziuban R. Growth and early bearing of apple trees, depending on the type of nursery trees used for planting. Proc. ISHS 8th Internat. Symp. on Integrated Canopy, Rootstock and Environmental Physiology in Orchard Systems, Acta Hort. [in press]
8. Sadowski A., Słowiński A., Dominiak R. and Kuras M. (2000) Quality of planting stock and productivity of apple trees. Proc. Intern. Conf. «Fruit Production and Fruit Breeding». Pub. Estonian Agric. Univ., 207, 37- 41.
9. Somorowski K. (1964) Nowe typy pigwy podkładkowej. Prace Inst. Sad. (Skierniewice) 8, 21-29.
10. Wertheim S.J. (1998) Rootstock guide, Apple, pear, cherry, European plum. Fruit Research Station, Wilhelminadorp, Netherlands, 61-84.
11. Wertheim S.J. and Balkhoven-Baart J.M.T. (1997) Rootstocks and interstems for pome and stone fruit Ann. Rep. for 1996. Wilhelminadorp Fruit Research Station, Netherlands, 9-10.

CHEMICAL SOIL PROPERTIES IN APPLE ROOTSTOCK STOOL-BEDS WITH SPECIAL EMPHASIS TO THE CONTENT OF COPPER
AUGSNES ĶĪMISKĀS ĪPAŠĪBAS ĀBEĻU POTCELMU MĀTESAUGU STĀDĪJUMĀ ĪPAŠI AKCENTĒJOT VARU

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Kopsavilkums

Ābeļu potcelmu mātesaugu rindās augsne saturēja vairāk organiskās vielas, fosfora, kālija, magnēzija un kopējo slāpekli, nekā blakus esošā starprindu augsne (kontroles variants). Šīs atšķirības tika konstatētas augsnes virskārtā un bija nozīmīgas tikai dažos gadījumos. Vairāk pētīto elementu (izņemot magnēziju) tika atrasti starprindu augsnē mātesaugu stādījumā nekā rindās. Vara satura palielinājums saistāms ar varu saturošo defoliantu lietošanu. Tomēr šis vara satura palielinājums mātesaugu stādījumā kopumā nav būtisks un tika konstatēts 0 – 25 cm dziļumā. Būtiski augstāks tas ir potcelmu mātesaugu rindu augsnē.

Abstract

Soil in apple rootstock stool-beds contained more organic matter, phosphorus, potassium, magnesium and total nitrogen than that in the nearby bare land (control field). These differences were evident mainly in the superficial soil layers and were significant only in some cases. Similarly, more of the examined elements (except for magnesium) were found in the soil between the rows of plants within the stool-beds than in the rows of rootstocks. The increase in total copper level in the soil used in stool-beds was observed over some consecutive years as a result of the use of rootstock defoliation compounds containing copper. Yet this Cu increase was not significant and it occurred in the soil layer 0 – 25 cm. deep. Significantly more copper was found in the soil taken from between the plant rows in stool-bed than from the stool beds.

Key words: stool-bed, soil, chemical properties, copper

Introduction

The number of rooted layers in the apple rootstock stool-bed varies between 30000 and 320000 per ha yearly, depending on the age of plants and type of rootstock (Rejman and Makosz, 1994). For effective rooting, shoots should have optimal conditions concerning chemical and physical soil properties. To improve these conditions and to control weed growth, sawdust is often used to mound the low parts of shoots. The volume of sawdust may reach 3000 m^3 per hectare. Layers are defoliated by hand and/or chemically and leaves remain in the plantation. We did not find in the literature any data dealing with the effect of sawdust on the chemical properties of the soil in stool-beds and on the impact of defoliants use (copper sulphate as Miedzian 50 WP and copper chelate as Insol 240 SL) on the copper content in the soil. The last problem is important because of the threat of possible environment pollution.

Materials and Methods

These studies were carried out in two stool-beds of the apple rootstock M.9 and M.26 situated in the Lublin area, Poland, on Haplic Luvisol type of soil. The chemical analyses of the soil (pH, organic matter, P_2O_5, K_2O, MgO, total N and total Cu) were done in 1999, 2000 and 2002 in soil from 0-25, 25-50, 50-75 and 75-100 cm level. Similar analyses were done in summer 2002 using soil taken from control plots situated close to the stool-beds, which was never used for nurseries or orchards. At the same time, soil samples were taken from stool-bed interrows and rows of rootstocks and then analysed. The following analytical methods for: pH in 1M KCl, organic matter by Tiurin, N by Kjeldahl, K and P by Egner-Riehm, Mg by Schachtschabel and Cu by ASA were used for all examined samples. The soil samples were taken from randomly selected plots in three replications separately from plant rows and interrows. The data was subjected to analysis of variance, and the mean separation of Duncan’s multiple range tests was used at P 0.05. Similar tendencies were found in both stool-beds, so the results are presented as means for both of them. Since 2000 chemical defoliation of layers was done every year according to Basak's (1999) recommendations.

The data were subjected to analysis of variance, and mean separation of Duncan's multiple range tests was used at $P<0.05$.

Results and Discussion

O r g a n i c   m a t t e r. Soil in the total profile (0 – 100 cm) in the stool-beds contained more organic matter than in the control plots. This was true only in two superficial layers, whereas in the deeper ones (50 – 75 and 75 – 100 cm) more organic matter was found in the soil from the control fields. The tendency towards the higher content of organic matter in the soil in alleyways was observed, especially in the layer 0 – 25 cm deep. These differences were, however, not significant.

P h o s p h o r u s. The content of this element was significantly higher in the whole soil profile in stool-beds in comparison with control plots. Differences were significant also in the layer 0 – 25 cm. deep. Also, soil in two superficial layers in the stool-bed interrows contained more P_2O_5 than in the rows (significantly in the level 25 – 50 cm)

P o t a s s i u m. Soil in the stool-beds contained more potassium than in control fields, especially in the superficial levels. However, these differences were not significant. There was more potassium in the soil in the alleyways than in the rows of rootstocks, with the exception for the layer 75 – 100 cm. deep.

M a g n e s i u m. Differences of magnesium between the soil in stool-beds and control plots were small and not significant, but somewhat pronounced in stool-beds in both deep layers only (50 – 100 cm). In all soil layers there was a tendency toward a higher content of magnesium in the rows of rootstocks than between them.

T o t a l   n i t r o g e n. The level of nitrogen was higher in all levels of the soil in stool-beds in comparison with control plots, but these differences were not significant. In the soil in the alleyways there was more nitrogen than in the rows, except the layer 50 – 75 cm deep.

S o i l   p H. In all layers studied, soil in the stool-beds was generally less acid than in control fields. Soil in the rows and between them did not differ significantly in this respect, although the tendency towards more acid soil in the rows in the layers 25 – 100 cm could be seen when compared with the soil from between the rows.

T o t a l   c o p p e r. The content of Cu steadily increased in all soil layers in stool-beds in the years 1999 – 2002, with the exception for the level 25 – 50 cm. This phenomenon was observed also when the whole soil profile was examined, i.e. the content of copper was 6.61; 7.10 and 7.49 mg kg^{-1} of dry soil for the years 1999, 2000 and 2002, respectively. Clearly a higher level of copper was found in two superficial layers of soil from alleyways when compared with the rows of rootstocks. However, this was contrary to the situation in the deeper layers. The layers of soil 0 – 25 and 75 – 100 cm deep in the stool-beds contained more copper than in control soil.

It is possible to point out tendencies in the changes of chemical properties in the soil between stool-beds and control fields as well as between the soil in rows and between them, inside stool-beds. However, significant differences were observed in a few cases only, mostly in the superficial layers of the soil (0 – 25 and 25 – 50 cm. deep). It could be concluded, that the soil in the stool-beds was richer in macroelements and organic matter than that in control plots, which has resulted from both fertilizing and use of sawdust. As compared with the rows of rootstocks, the soil in the alleyways contained more of almost all elements studied (except for magnesium). However, this was mainly in the superficial layers. In the layers deeper than 50 cm. all these differences were small. This phenomenon could be explained by the fact that the soil surface between the rows is lower that that in the rows as a effect of mounding the plants. So all the leaves as well as fertilizers tended to accumulate between rows. This would also explain the fact that more copper was found in the soil of the alleyways. The content of copper in this layer increased steadily in consecutive years. The highest content of this element was observed in two deep layers (50 – 100 cm.), but its concentration was far less than considered by Siuta (1995) as medium for Polish soils (15 mg) and recently found in the orchard soil near Szczecin (Ostrowska *et al.*, 2004).

Table 1. Some chemical properties of soil in stool-beds and in control field

Chemical properties	Position in stool-bed		Stool-bed	Control field
	rows	alleyways		
Organic matter %				
Whole profile	0.86 a	1.03 a	0.95 a	0.73 a
Soil layers: 0 – 25	1.74 a	2.75 a	2.25 a	1.47 a
25 – 50	1.15 a	0.83 a	0.99 b	0.38 a
50 – 75	0.37 a	0.19 a	0.28 a	0.60 a
75 – 100	0.19 a	0.35 a	0.27 a	0.48 b
P_2O_5 mg · 100 g^{-1}				
Whole profile	9.81 a	12.47 a	11.14 b	8.20 a
Soil layers: 0 – 25	16.55 a	23.10 a	19.82 b	8.55 a
25 – 50	6.98 a	12.98 b	9.97 a	6.72 a
50 – 75	8.12 a	7.17 a	7.65 a	10.05 a
75 – 100	7.57 a	6.62 a	7.10 a	7.45 a
K_2O mg · 100 g^{-1}				
Whole profile	9.53 a	11.94 a	10.74 a	8.36 a
Soil layers: 0 – 25	14.25 a	21.00 b	17.62 a	13.10 a
25 – 50	9.67 a	13.25 a	11.46 a	8.05 a
50 – 75	7.42 a	8.20 a	7.81 a	6.72 a
75 – 100	6.75 a	5.27 a	6.01 a	5.57 a
MgO mg · 100 g^{-1}				
Whole profile	9.53 a	7.98 a	8.76 a	7.93 a
Soil layers: 0 – 25	7.35 a	6.50 a	6.93 a	6.78 a
25 – 50	7.68 a	6.60 a	7.14 a	7.10 a
50 – 75	11.28 a	9.80 a	10.54 a	8.95 a
75 – 100	11.80 a	9.02 a	10.41 a	8.95 a
N – total %				
Whole profile	0.061 a	0.070 a	0.066 a	0.058 a
Soil layers: 0 – 25	0.090 a	0.102 a	0.096 a	0.095 a
25 – 50	0.050 a	0.087 a	0.068 a	0.052 a
50 – 75	0.062 a	0.045 a	0.054 a	0.045 a
75 – 100	0.042 a	0.045 a	0.044 a	0.040 a
pH				
Whole profile	5.42 a	5.52 a	5.47 b	4.60 a
Soil layers: 0 – 25	5.81 a	5.45 a	5.63 b	4.48 a
25 – 50	5.50 a	6.01 a	5.76 b	4.52 a
50 – 75	5.33 a	5.49 a	5.41 b	4.73 a
75 – 100	5.03 a	5.11 a	5.07 b	4.66 a
Copper total, mg kg^{-1}				
Whole profile	6.51 a	7.49 a	7.00 a	7.43 a
Soil layers: 0 – 25	5.41 a	8.24 b	6.82 a	6.16 a
25 – 50	4.41 a	5.58 a	4.99 a	6.82 a
50 – 75	7.24 a	7.58 a	7.41 a	9.74 a
75 – 100	8.99 a	8.57 a	8.78 a	6.99 a

* in 2002

Table 2. Details concerning the content of copper in the soil, mg kg^{-1} dry soil

Soil layers	Position in stool-bed				Control field 2002
	rows	Alleyways			
	2002	1999	2000	2002	
Whole profile	6.51	6.61	7.10	7.49	7.43
0 – 25	5.41	6.33	7.49	8.24	6.16
25 – 50	4.41	6.99	5.25	5.58	6.82
50 – 75	7.24	6.41	7.00	7.58	9.74
75 - 100	8.99	6.71	8.66	8.57	6.99

Conclusions

Soil in stool-beds contained generally more macroelements and organic matter than in the control fields and it was less acid.

The content of copper in soil increased with years, but in the superficial layer (0 – 25 cm. deep) only. However it remained lower than quoted in the literature.

Reference

1. Basak A.(1999) Defoliacja zabieg poprzedzający ekspedycję materiału szkółkarskiego. Owoce, Warzywa, Kwiaty, 17/18, 7-9.
2. Ostrowska K., Mikiciuk G., Chełpiński P., Chudecka J. and Grajkowski J. (2004) Zawartość makro i mikroelementów w glebie płowej utrzymywanej w czarnym ugorze i pod murawą w sadzie czereśniowym. Folia Univ. Agric. Stetin, Agricultura, 240 (96), 137-141.
3. Rejman A. and Makosz E. (1994) Szkółkarstwo roślin sadowniczych. Plantpress, Kraków.
4. Siuta J. (1995) Gleba. Diagnozowanie stanu i zagrożenia. Warszawa, IOŚ.

SEED DORMANCY AND ROOTSTOCK QUALITY OF SIX GENOTYPES OF CAUCASIAN PEARS
KAUKĀZA BUMBIERU GENOTIPU IZVĒRTĒJUMS PĒC SĒKLU MIERA PERIODA UN POTCELMU KVALITĀTES

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Kopsavilkums

Izmēģinājumā noskaidrots sešu Kaukāza bumbieru (*Pyrus communis* var. *caucasica* Fed.) genotipus: GK1, GK2, GK3, 'Elia', 'Belia' un 'Doria' sēklu miera perioda ilgums un dīgšanas spars svaigām un izžāvētām sēklām. Papildus tika izvērtēta 'Elia', 'Belia' un 'Doria' potcelmu kvalitāte. Sēklu miera perioda pārtraukšanai tika izmantotas divas metodes: svaigu un izžāvētu sēklu stratifikācija mitrā sfagnu kūdrā un parasti lietotā sausu sēklu stratifikācija. Aprīlī sēklas tika pārvietotas uz neapkurināmām plēves siltumnīcām un apkurināmām siltumnīcām. Visos veidos stratificēto sēklu sējeņi tika izstādīti vienā laikā. Pētītie genotipi atšķīrās pēc miera perioda ilguma, dīgšanas spara un kvalitatīvo sējeņu gala iznākuma. Vēlo genotipu sēklām bija īsāks miera periods, nekā agrāko genotipu sēklām. Sējeņu augstums un diametrs būtiski neatšķīrās starp stratifikācijas veidiem. Tomēr to sējeņu sakņu sistēma, kuri iegūti no mitrā kūdrā stratificētajām sēklām, bija labākas kvalitātes nekā tradicionāli laukā sēto sējeņu sakņu sistēma.

Abstract

The aim of this study was to assess the length of the after-ripening period and the germination capacity of fresh and dried seeds of six Caucasian pear (*Pyrus communis* var. *caucasica* Fed.) genotypes: GK1, GK2, GK3, 'Elia', 'Belia' and 'Doria'. Additionally, important traits of rootstocks obtained from 'Elia', 'Belia' and 'Doria' seeds were compared. Two methods of after-ripening of seeds were applied: stratification of individual fresh or dry seeds in trays filled with moist sphagnum peat and conventional stratification of dry seeds. At the beginning of April, after stratification treatments, trays were transferred to an unheated plastic tunnel or to a heated glasshouse. Finally, young seedlings obtained in the unheated plastic tunnel, were planted in the same field where seedlings raised from conventionally stratified and sown directly in the field seeds, were grown. The studied genotypes differed in length of dormancy, germination rate and final output of seedlings obtained. Seeds from the late-ripening genotypes had a shorter dormancy period than seeds obtained from the early ripening types. Height and diameter of rootstocks did not significantly differ between treatments. However, rootstocks raised in trays had a better root system than those raised by sowing directly in the field.

Key words: pear genotypes, seed dormancy, stratification methods, seed germination, rootstock quality

Introduction

Common Caucasian pear (*P. communis* var. *caucasica* Fed.), a generative rootstock for pears, replaced between the first and second world war previously used in Poland common pear (*Pyrus communis* L.). The main advantage of the Caucasian pear is its resistance to leaf blight of pear (*Entomosporium maculatum* Lév.) and a more vigorous growth in the nursery than that of common pear (Wierszyłłowski, 1936). Presently, seedlings of Caucasian pear make up about 75% (1.5 million) of the total annual production of pear rootstocks in Poland (Grzyb, 2005). The Institute of Pomology and Floriculture of Skierniewice introduced three cultivars of Caucasian pear, Elia, Belia and Doria, which have been recommended as generative rootstocks for pears since 1994 (Rejman *et al*., 2002). At the Department of Pomology, WAU, three other genotypes of *P. communis* var. *caucasica*, GK1, GK2 and GK3, have also been under evaluation (Odziemkowski *et al*., 2004). Fruits of Caucasian pear genotypes ripen at different time. This may result in differences of the length of seed dormancy. Information concerning nursery value of seeds and of seedlings of *P. communis* var. *caucasica* and of the recommended cultivars in particular is scarce. The aim of this study was to assess the length of after-ripening period necessary for overcoming dormancy of the fresh seeds extracted from fruits stored at 2-3° C till stratification, in comparison with the dry seeds. Germination capacity of six Caucasian pear (*P. communis* var. *caucasica* genotypes was also compared. Additionally, important traits of rootstocks obtained from three above-mentioned cultivars were evaluated.

Materials and Methods

General information. The fruits of 'Elia', 'Belia' and 'Doria' were collected from clone seed trees grown on seedling rootstocks. The seed orchard was located at Kuźnice (Kujawy region). Trees of selections GK1, GK2 and GK3, were grown on own roots at the Experimental Farm of the Department of Pomology, Warsaw Agricultural University (WAU) in Warsaw-Wilanów, where the experiment 1 was conducted. Fruits of 'Elia' ripened about one week earlier than 'Belia', three weeks earlier than GK1 and four weeks earlier than fruits of 'Doria', GK2 and GK3. Dry seeds of 'Elia', 'Belia' and 'Doria' for the experiment 1, and of GK1, GK2 and GK3 for the experiment 2 were obtained in Warsaw after extracting them from mature fruits and drying at room temperature at 20 ± 2°C. Dry seeds of 'Elia', 'Belia' and 'Doria' for the experiment 2 were obtained from the nursery at Kuźnice, where they were dried for commercial use. They originated from the crop of 2004. Average moisture content of all dried seeds before stratification treatments varied from 8.7% ('Elia') to 10.5% (GK3).

After-ripening methods. Two methods of after-ripening of seeds were used: individual stratification (IS) of fresh or dry seeds and conventional stratification (CS) of dry seeds. Individual fresh seeds (F), extracted at different time from fruits stored at 2-3°C after harvest or dry stored seeds (D) were sown 1.5 cm deeply into 70-cm^3 trays, filled with a moist sphagnum peat supplemented with mineral nutrients. Then they were placed in common cold storage at 2-3°C, for different periods (depending on the treatment), and finally transferred to an unheated plastic tunnel at the beginning of April. Dry seeds were soaked in water for 24 hours, before stratification treatment. CS of dry seeds was conducted in 0.5-dm^3 pots filled with mixture of moist sphagnum peat and sand (1:1). All after-ripening treatments of seeds were carried out in a cold storage, at 2-3°C.

Experiment 1. Fruits of 'Elia', 'Belia' and 'Doria' were harvested on September 11, 2003, then transferred to Warsaw-Wilanow. Most of them were stored at 2-3°C until extracting seeds for stratification treatments of fresh seeds. On the second day after picking, from another part of fruits of 'Elia' and 'Belia' seeds were extracted, dried and stored in a refrigerator. The same procedure was followed with a part of fruits of 'Doria', but extraction of seeds from fruits was done two weeks later. In this experiment nine after-ripening treatments for each of three cultivars were applied, listed in the Table 1. Six of them consisted of fresh seeds (F) and three of dry seeds (D), as follows.

(1) $^{F+T}$– after-ripening of seeds in fruits during cold storage till April 8, 2004; then individual sowing into trays (^{T}), filled with moist sphagnum peat;

(2) $^{IS, F}$– individual stratification (^{IS}) of fresh seeds for 34 days, from March 6 to April 8, 2004;

(3) $^{IS, F}$ to **(**6) $^{IS, F}$ – like treatment 2 $^{IS; F}$, differences were only in the length of fruits storage and length of the seed stratification treatment (49, 64, 79 or 94 days);

(7) $^{IS, D}$ – individual stratification (^{IS}) of dry seeds for 114 days, from December 17, 2003 till April 8, 2004;

(8) $^{CS, D+T}$– conventional stratification (^{CS}) of dry seeds for 114 days, from December 17, 2003 till April 8, 2004, then individual sowing into trays (^{T}) filled with moist sphagnum peat.

(9) $^{CS, D}$– conventional stratification (^{CS}) of dry seeds (^{D}) for 119 days, from December 12, 2003 till April 8, 2004, then sowing directly in the outdoor nursery.

There were 4 replications, each consisting of 60 seeds. On April 9, 2004 all trays from the treatments (1)-(8) were placed in the unheated plastic tunnel.

Additional samples of seeds (reference treatment) were used for the germination test, which was done after each after-ripening treatment. These samples were taken in 4 replications, each of 25 seeds. Seeds, which germinated in pots in the cold storage, were recorded after stratification treatment and discarded (Table 1, data in parenthesis). The remaining seeds were germinated in the laboratory at 16-24°C. Emergence of seedlings in the unheated plastic tunnel or in the field was evaluated when cotyledons emerged above the surface of sphagnum peat in pots or above the soil in the outdoor nursery. Germinated seeds and emerged seedlings were recorded daily. The emergence rate of seedlings was expressed as an average number of days required for cotyledons to emerge above the surface of sphagnum peat in pots, according to Hartmann et al. (1997). Trays in the plastic tunnel were mist-irrigated. On May 26, 2004, young seedlings from the treatments from (1) $^{F+T}$ to (8) $^{CS, D +T}$ were planted in the nursery in a randomised design in 4 replications, each consisting of 30 plants. In the autumn, rootstocks were dug out and their height, diameter, number of lateral roots and number of seedlings infected by crown gall [*Agrobacterium tumefaciens* (Smith et Town) Conn.] were recorded.

Experiment 2. Mature fruits were harvested in 2004; 'Elia' and 'Belia' on September 16, 'Doria' on October 6, GK1 on October 7, GK2 and GK3 on October 14. The following after-ripening treatments were applied (Table 2):

(1) $^{IS, F}$ to (3) $^{IS, F}$ – IS of fresh seeds for 38, 59 or 80 days, till April 14, 2005,
(4) $^{IS, D}$ and (6) $^{IS, D}$ – IS of dry seeds for 80 or 101days respectively till April 14, 2005,
(5) $^{CS, D+T}$– conventional stratification of dry seeds for 87 days, from January 17 till April 14,2005; then seeds were individually sown (^{IS}) into trays (^{T}) with moist sphagnum peat.

There were 6 replications, each consisting of 30 seeds. On April 15, 2005, trays of all treatments were placed in a heated glasshouse, at 20°C ±2. Emergence of seedlings in the heated glasshouse was assessed when cotyledons emerged above the surface of sphagnum peat moss in pots. The emerged seedlings were recorded daily. The results were elaborated by analysis of variance analysis, separately for each genotype. The significance of differences between treatment means was evaluated using the Tukey test, at α=0.05.

Results and Discussion

Experiment 1. Genotypes of 'Elia', 'Belia' and 'Doria' differed in seed germination and in the output of seedlings (Table 1). The percentage of germinated seeds of 'Doria' was the highest (93-100%) at any length of stratification (34, 64, 79 or 94 days), when IS fresh seeds (from fruits stored in cold storage) were used (Table 1). A similar percentage germinated seeds was recorded in 'Belia', after 49, 64 and 94 days of stratification of IS fresh seeds. Seeds of 'Elia' germinated in the lower proportion than seeds of 'Belia' or 'Doria'. The highest percentage of seeds (80%) of 'Elia', which overcame dormancy, was recorded in the treatment 3, where fresh seeds were individually stratified (IS) for 49 days. After IS of fresh seeds for 34 days, only 64% of seeds of 'Elia' passed dormancy, in comparison to 87% of such seeds of 'Belia' and 95% of 'Doria'. In case of the IS of dry seeds, the same influence of the genotype on percentage of germinated dry seeds was noted. This suggests that seeds of 'Elia' had a longer dormancy period than 'Belia', and longer than 'Doria' in particular.

The percentage of seedlings obtained in the unheated plastic tunnel depended on the genotype and on the after-ripening treatment (Table 1). The average percentage of seedlings obtained from all treatments was the highest (77%) in case of 'Doria' and the lowest (56%) for 'Elia'. With extending the IS of fresh seeds from 34 to 49 days, the output of seedlings was stable for 'Doria' (90%) and slightly increased in case of 'Elia' and 'Belia'. If the IS of fresh seeds was extended more – to 64, 79 and 94 days, the effect of this increase upon the output of seedlings was erratic, especially in case of 'Elia'. Nevertheless it was the highest after the 94-day IS of fresh seeds for all examined genotypes. The highest output of seedlings (80%) of 'Elia' was obtained from dry seeds,. conventionally stratified (CS), for 119 days and then directly sown in the nursery (treatment 9 $^{CS, D}$).

Height and diameter of rootstocks 'Elia', 'Belia', 'Doria' did not depend on stratification treatments. However, rootstocks raised in trays had a better root system than those raised by sowing directly in the field. In 2004, the crown gall [*Agrobacterium tumefaciens* (Smith et Town) Conn.] infected roots of majority (61-80%) of seedlings rootstocks produced by traditional method. An unexpected reduction of crown gall incidence (down to 2-23%) was obtained in treatments involving use of sphagnum peat and this may present a special interest (Table 1).

Table 1. The effect of after-ripening treatment on seed germination, emerges of seedlings of the common 'Caucasian' pear (*Pyrus communis* var. *caucasica* Fed.) in the unheated plastic tunnel and on the quality of rootstocks obtained in the nursery (2004)

Treatment No. and code	Period of cold storage of fruits, days	Stratification at 2-3°C, days	Percent of seeds		Mean number of days for emergence of one seedling	Characteristics of rootstocks			
			germinated^{x}	emerged		Diameter mm	Height, cm	Number of lateral roots	Percent of rootstocks with crown gall
‘ELIA‘									
1^{F+T}	211	0	0 a	18 a	18.2 g	9.1 a	45 a	5.7 b	8 a
2$^{IS, F}$	177	34	64 (23) c	60 c	8.8 d	9.0 a	47 a	5.7 b	10 a
3$^{IS, F}$	162	49	80 (76) d	66 c	7.2 c	9.6 a	50 a	5.9 b	18 a
4$^{IS, F}$	147	64	47 (47) b	42 b	5.6 b	8.9 a	46 a	5.6 b	4 a
5$^{IS, F}$	132	79	64 (64) c	51 bc	4.6 b	9.1 a	47 a	6.7 b	4 a
6$^{IS, F}$	117	94	72 (72) cd	68 cd	3.9 a	9.4 a	49 a	6.1 b	5a
7$^{IS, D}$	0	114	57 (0) bc	57 bc	10.6 e	9.0 a	46 a	5.6 b	9 a
8$^{CS, D +T}$	0	114	50 (3) b	66 b	11.1 e	9.4 a	48 a	6.0 b	3 a
9$^{CS, D}$	0	119	-	80 d	16.0 f	8.8 a	50 a	1.3 a	80 b
Average of nine treatments			54	56	9.5	9.1	48	5.4	16
‘BELIA’									
1^{F+T}	211	0	2 (0) a	15 a	18.2 f	9.4 a	42 a	5.6 bc	12 ab
2$^{IS, F}$	177	34	87 (34) c	83 c	9.3 d	8.7 a	44 a	6.0 bc	2 a
3$^{IS, F}$	162	49	97 (87) d	85 c	7.1 d	9.3 a	46 a	5.6 bc	21 b
4$^{IS, F}$	147	64	92 (89) cd	67 bc	6.2 b	9.1 a	45 a	6.0 bc	19 ab
5$^{IS, F}$	132	79	89 (84) c	73 bc	4.8 a	9.3 a	45 a	6.3 c	23 b
6$^{IS, F}$	117	94	100 (100) e	82 c	4.2 a	9.1 a	45 a	5.0 b	11 ab
7$^{IS, D}$	0	114	71 (8) b	61 b	10.1 de	9.2 a	45 a	6.3 c	20 ab
8$^{,CS, D +T}$	0	114	78 (8) bc	74 bc	10.6 e	8.7 a	46 a	5.9 bc	8 ab
9$^{CS, D}$	0	119	-	77 c	17.7 f	8.9 a	58 b	1.2 a	77 c
Average of nine treatments			77	69	9.8	9.1	46	5.3	21
‘DORIA’									
1^{FT}	199	0	2 (0) f	18 a	18.7 g	8.9 a	33 a	4.1 b	4 a
2$^{IS, F}$	165	34	95 (0) bc	90 c	10.4 d	8.6 a	40 b	5.3 c	12 a
3$^{IS, F}$	150	49	93 (52) bc	90 c	8.9 c	8.8 a	40 b	5.6 b	7 a
4$^{IS, F}$	135	64	98 (85) b	83 bc	6.3 b	8.8 a	39 ab	5.4 c	10 a
5$^{IS, F}$	120	79	96 (92) bc	81 bc	5.9 b	8.5 a	40 b	5.6 c	4 a
6$^{IS, F}$	105	94	100 (100) a	86 bc	4.6 a	8,5 a	40 b	4.9 bc	5 a
7$^{IS, D}$	0	114	92 (44) c	86 bc	9.2 c	8.6 a	43 b	6.0 c	4 a
8$^{CS, D +T}$	0	114	72 (6) d	77 b	11.4 e	8.6 a	40 b	6.1 c	10 a
9$^{CS, D}$	0	119	-	86 bc	16.3 f	8.1 a	47 b	1.4 a	61 b
Average of nine treatments			81	77	10.2	8.6	40	4.9	13

^{x} Total percentage of germinated seeds – in laboratory test at 16-24ºC + seeds germinated in pots in cold storage (data in parentheses)

^{F} fresh seeds; ^{D} dried seeds; ^{T} trays; IS – individually stratified seeds; CS – conventionally stratified seeds.

Means followed by the same letter within the same group of seeds do not differ at the 5% level of significance.

E x p e r i m e n t 2. Out of three treatments of IS of fresh seeds the 38-day stratification appeared sufficient for overcoming dormancy of treated fresh seeds of six genotypes (Table 2). From these seeds, in a heated glasshouse, a high or very high output of seedlings was obtained from the genotypes GK3, GK1 and GK2 (91-100%), as well as from the cultivars Doria, Belia and Elia (84-89%). Extending the duration of IS of fresh seeds from 38 to 80 days, resulted in a slight (not significant) reduction of the percentage of seedlings obtained. After the 80-day IS of dry seeds of the early ripening genotypes 'Elia' and 'Belia', only 17 and 14% seedlings was obtained, in comparison to 57, 88, 96 and 97% of seedlings obtained from seeds of the late-ripening genotypes ('Doria', GK3, GK2 and GK1), treated in the same way.

Extending the duration of IS of dry seeds from 80 to 101 days, resulted in an increase of the output of seedlings up to 64% ('Elia'), 68% ('Belia') and 95% ('Doria').

Table 2 . The effect of the after-ripening treatment on the emergence of seedlings of the common 'Caucasian' pear (*P. communis* var. *caucasica*) in a glasshouse at 20°C ±2, 2005

Treatment No.and code	Period of cold storage of fruits, days	Period of stratification at 2-3°C, days	Percentage of emerged seedlings	Mean number of days for emergence of one seedling
GK 1				
1 $^{IS, F}$	152	38	98 a	3.8 b
2 $^{IS, F}$	131	59	95 a	2.3 c
3 $^{IS, F}$	110	80	97 a	1.6 c
4 $^{IS, D}$	0	80	97 a	3.7 b
5 $^{CS, D +T}$	0	87	82 b	4.8 a
6 $^{IS, D}$	0	101	98 a	2.1 c
Average of six treatments			95	3.0
GK 2				
1 $^{IS, F}$	145	38	100 a	4.1 a
2 $^{IS, F}$	124	59	99 ab	2.5 b
3 $^{IS, F}$	103	80	98 ab	1.7 c
4 $^{IS, D}$	0	80	96 ab	2.7 b
5 $^{CS, D +T}$	0	87	92 b	3.6 a
6 $^{IS, D}$	0	101	98 ab	1.7 c
Average of six treatments			98 a	2.7 c
GK 3				
1 $^{IS, F}$	145	38	91 a	4.0 a
2 $^{IS, F}$	124	59	94 a	2.4 b
3 $^{IS, F}$	103	80	89 a	2.1 b
4 $^{IS, D}$	0	80	88 a	2.1 b
5 $^{IS, D}$	0	101	88 a	1.8 b
6 $^{CS, D +T}$	0	87	86 a	3.5 a
Average of six treatments			89	2.7
'ELIA'				
1 $^{IS, F}$	145	38	89 a	2.3 c
2 $^{IS, F}$	124	59	78 a	1.5 d
3 $^{IS, F}$	103	80	71 ab	1.6 d
4 $^{IS, D}$	0	80	17 c	7.3 a
5 $^{CS, D +T}$	0	87	55 b	6.9 a
6 $^{IS, D}$	0	101	64 ab	5.9 b
Average of six treatments			63	4.3
'BELIA'				
1 $^{IS, F}$	173	38	87 a	2.9 c
2 $^{IS, F}$	152	59	86 a	1.6 d
3 $^{IS, F}$	131	80	81 a	1.6 d
4 $^{IS, D}$	0	80	14 c	7.4 a
5 $^{CS, D +T}$	0	87	59 b	6.9 a
6 $^{IS, D}$	0	101	68 ab	5.7 b
Average of six treatments			67	4.3
'DORIA'				
1 $^{IS, F}$	153	38	84 ab	3.6 c
2 $^{IS, F}$	132	59	86 ab	2.0 d
3 $^{IS, F}$	111	80	80 b	1.5 d
4 $^{IS, D}$	0	80	57 c	7.2 a
5 $^{CS, D +T}$	0	87	66 bc	7.1 a
6 $^{IS, D}$	0	101	95 a	4.4 b
Average of six treatments			80	4.3

[1] For explanations see table

Using two methods and different period of stratification of fresh seeds (extracted from fruits stored in cold storage at 2-3°C) and of dry seeds, a clear influence of genotypes of Caucasian pear on the length of seed dormancy was shown. Seeds of genotypes, fruits of which ripened early ('Elia', 'Belia') had a longer length of dormancy and needed a longer stratification period than those ripening later (GK1, GK2, GK3, and 'Doria'). This phenomenon was observed earlier in the seeds of apple cultivars by Daskalyuk *et al*. (1996).

Seeds from fruits stored at 2-3ºC needed a shorter period of stratification than dry seeds. It was also found by various investigators in apple seeds (Bartlett, 1961; Grzyb *et al*., 1969, Pitera and Odziemkowski, 2003). Certainly, storage ability of early ripening fruits of 'Elia' and 'Belia' was much lower then those ripening late (especially GK1, GK2, GK3). This should be considered in choosing dry or fresh seeds, for stratification treatment.

In our experiments, 100 days of individual stratification were sufficient to overcome the dormancy of dry seeds of GK3, GK1 and GK2 but insufficient for dry seeds of 'Elia' and 'Belia'. This suggests that dry seeds of some pear genotypes, for complete overcoming of their dormancy, need a longer, ca 120-day, stratification period. This length of stratification treatment of dry seeds is still under evaluation.

The rootstocks raised in trays had a better root system than those raised by sowing directly in the field. In 2004 crown gall [*Agrobacterium tumefaciens* (Smith *et* Town) Conn.] infected the roots of the majority of seedling rootstocks produced by traditional method. An unexpected reduction of crown gall incidence was obtained in treatments involving use of sphagnum peat and this may present a special interest. This phenomenon is also under further investigation.

Conclusions

Seed dormancy period differs between particular genotypes of Caucasian pears. Seeds of genotypes, fruits of which ripen early, need a longer after-ripening period than seeds of late-ripening genotypes.

Dry seeds need a longer stratification period than fresh seeds, extracted from fruits stored at 2-3ºC.

Seeds from fruits stored at 2-3°C and then individually stratified in trays for 40-60 days at 2-3ºC germinated at a high percentage.

Seedlings raised with in seed trays and then planted in the field develop abundant lateral roots.

References

1. Bartlett C.E.C. (1961) The after-ripening of apple seeds in the fruit during cold storage. Ann. Rep. Agr. and Hort. Long Ashton. Res. Sta. Bristol, 66–67.
2. Daskalyuk A.P., Toma O.K., Yarotskaya L.V. and Nikita I.I (1996) Seed germination and polypeptide composition in early- and late-ripening apple cultivars as related to stratification time. Russian Journal of Plant Physiology, 43, 4, 504-509.
3. Grzyb Z.S., Zagaja S.W. and Kamiński W. (1969) Przebieg posprzętnego dojrzewania nasion w przechowywanych owocach jabłoni. Prace Instytutu Sadownictwa w Skierniewicach, 13, 39-50.
4. Grzyb Z. (2005) Zapotrzebowanie na nasiona drzew owocowych. Szkółkarstwo, 2, 60-62.
5. Hartmann, H.T., Kester, D.E., Fred, T., Davies, F.T. and Geneve, R.L. (1997) Plant propagation: Principles and practices. 6th ed. Prentice-Hall, Upper Saddle River, New Jersey.
6. Odziemkowski S., Pitera E. and Ścibisz K. (2004) Wstępna ocena przydatności nowej technologii produkcji podkładek generatywnych gruszy kaukaskiej. Zeszyty Naukowe Instytutu Sadownictwa i Kwiaciarstwa w Skierniewicach, 12, 251-256.
7. Pitera E. (2003) Przydatność klonu U 211 w hodowli odpornościowej jabłoni. Rozprawy Naukowe i Monografie. Wydawnictwo SGGW, Warszawa, 106.
8. Pitera E., Odziemkowski S. and Dąbrowska B. (2004) Improvement of seed germination in apple breeding. Acta Hort., 663, 783-787.
9. Rejman A., Ścibisz K. and Czarnecki B. (2002) Szkółkarstwo roślin sadowniczych. PWRiL, Warszawa, 292.
10. Wierszyłłowski J. (1936) Studia nad gruszą kaukaską jako podkładką. Roczniki Nauk Ogrodniczych, 3, 263-268.

EFFECT OF LOCALITY ON THE GROWTH OF STRAWBERRIES GROWN IN RHIZOBOXES
AUGŠANAS VIETAS IETEKME UZ ZEMEŅU AUGŠANU, AUDZĒJOT TĀS RIZOKONTEINEROS

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Kopasavilkums

`Senga Sengana` šķirnes sējeņi tika iestādīti (2003. – 2004.) rizokonteineros, kuri saturēja 1.7 kg augsnes, kura ņemta no 5 dažādām vietām: ābeļu rindu vietas pēc 20 gadu ābeļu augšanas; herbicīdu apstrādātas apdobju vietas 20 gadus auguša ābeļdārzā; augsne no starprindu zālāja 20 gadu vecā ābeļdārzā; no bijušā ābeļdārza vietas, kur 4 gadus augsne nav izmantota un augsne no lauksaimniecībā izmantojamas platības. Sējeņi konteineros auga trīs mēnešus. Pētījumā konstatēts, ka augšanas vietai ir ietekme uz lapu virsmas izmēru, kā arī sakņu un sakņu kakliņu masu. Augsnē, kurā ilgstoši augušas ābeles, zemeņu augums parametri bija būtiski sliktāki. Zemenes var izmantot kā augsnes noguruma indikatoraugus, jo tās labi reaģē uz augsnes nogurumu.

Abstract

The objective of the presented study was the evaluation of the effect of diversified soil localities on the growth and yield of strawberries; they were carried out in the vegetation period 2003 and 2004. Strawberry seedlings of Senga Sengana cultivar were planted in rhizoboxes containing 1.7 kg of soil. Soils from 5 localities were used in the experiments with the following combinations in three replications: 1- soil from apple-tree rows which were dug up after 20 years of cultivation, 2-soil from herbicide fallow rows used in apple orchards for 20 years, 3-soil from grass belts in apple orchards cultivated for 20 years, 4- soil from apple orchards which was cleared and thereafter was not used for four years, 5-soil on which agricultural plants were grown. Strawberry seedlings were grown for a period of three month using irrigation when it was necessary. After the liquidation of the experiments, the following measurements were carried out: surface of leaf blades, diameter of root neck, mass of root neck, mass of roots. Results of our investigations showed that:

- strawberries growing in rhizoboxes showed a differentiated effect of the locality on their growth measured by leaf blade surface area and by the mass of roots and root necks.
- apple-trees grown for many years in the same locality significantly decreased strawberry growth expressed by the total leaf blade surface area and by the mass of root and root necks.
- strawberry reacts strongly to soil fatigue and it can be a good plant for testing fatigue occurrence in the orchard because strawberries grown in a new ground had the best growth conditions.

Keywords: strawberry, replant soil, growth

Introduction

Success in strawberry growing depends to a high degree on the selection of locality. The type of soil, the level of underground waters and the fore crop are important factors. They are particularly significant in case of a shortened production period which requires replanting (successive growing of the same species) resulting in soil fatigue, which is a nuisance to the producers all over the world (Hoestra, 1994; Aldea 1998).

Many scientists have dealt with soil fatigue for decades, but in spite of that, this phenomenon has not been fully solved. However, the effects are very well known like poor growth, lower yield, reduction of the leaf blade surface area and even death of the whole plant (Constante *et a*., 1991).

One of the methods limiting the negative effect of soil fatigue on plants is the change of the grown species or the application of a 4-year break in plant growing.

The objective of the study conducted in the years 2003-2004 was the evaluation of diversified soil localities on the growth of strawberries.

Materials and Methods

The stady was carried out in the Fruit Growing Department of Agricultural University in Poznań in three cycles in the vegetation terms 2003-2004:

- cycle I - strawberries were grown in the period 28.06 - 28.09 2003;
- cycle II - strawberries were grown in the period 28.04 — 28.07 2004;
- cycle III - strawberries were grown in the period 4.08 — 8.11 2004.

The object of the study was the soil of a replanted apple orchard with Topaz cultivar on M-26 rootstocks established in spring 2000. The soil had been used as an apple orchard for 20 years and it showed a differentiated degree of fatigue in comparison with an orchard established on a new ground (where the soil was agriculturally used before).

Strawberry 'Senga Sengana' cultivars was grown on five plots as a test plant:

- locality 1: trees were planted in rows after the removal of apple trees which had been grown there for 20 years;
- locality 2: trees were planted in belts of pesticide fallow used for 20 ears;
- locality 3: trees were planted in turf belts used for 20 years;
- locality 4: trees were planted in a place where apple trees had been grown for 16 years followed by a 4 -year break in the cultivation;
- locality 5: trees were planted in a fresh soil.

Rhizoboxes (37x18x7 cm) of 1.7 kg capacity were filled with soil taken from the particular localities in the orchard.

In order to facilitate root growth in the direction of transparent walls, the rhizoboxes with plants were placed in such a way that the wall was inclined to the earth surface under an angle of about 50-60° and the boxes were covered with black foil in order to limit light access.

After two months of strawberry cultivation, the experiment was liquidated and the plants were subject to the following measurements:

- leaf blade surface - of all leaves from each plant (cm^2);
- root neck diameter - of each plant (mm);
- root neck mass - of each plant (g);
- root mass - of each plant (g).

The obtained results were statistically analyzed by Anowa using Duncan criteria and significant differences were determined at the significance level of a=0.05.

Results and Discussion

One of the important determinants of plant growth, according to Listowski (1970), are the measurement changes, primarily in the growth, volume and weight which depend on the environmental factors such as soil or climate. Studies carried out in the vegetation seasons of 2003 and 2004 aimed at the determination of soil locality on the growth of strawberries grown in rhizoboxes. On this basis, it was found that the locality and particularly the way of the earlier utilization of the given soil exerted an essential effect on the plant growth measured by the leaf blade surface area. Independent of the growing cycle the smallest mean leaf blade surface area was found in strawberries grown in the soil of a replanted orchard within the belts of herbicide fallow and in the rows of old trees (Table 1). Leaf blades with the greatest surface areas were found in strawberries grown in the soil from the apple orchard established on a new ground, they reached 87,8 cm^2 (Table 1). This differentiation is particularly visible in the calculation of the total leaf blade surface area varied between 535.9 cm^2 in soil taken from an orchard established in the rows of old trees and 1004.4 cm^2 in the soil from orchard established on a new ground.

Such great differentiation in the growth of the above ground plant parts confirms the thesis about the fatigue of soil created by apple-trees grown for many years in monoculture (Hoestra, 1994; Pacholak, 1997).

Table 1. Effect of locality on the growth of strawberries (mean of years 2003-2004)

Locality	Mean leaf blade surface, cm^2	Total leaf blade surface, cm^2	Root mass, g	Root neck mass, g
1	57.3 a*	535.9 a	6.0 a	4.0 a
2	56.8 a	569.6 a	8.9 bc	5.6 b
3	65.6 ab	678.7 a	11.2 cd	5.4 ab
4	68.4 b	589.9 a	7.1 ab	4.1 a
5	87.8 c	1004.4 b	12.8 d	5.7 b
Cycle 1	81.5 b	932.9 c	15.6 b	7.3 c
Cycle 2	57.3 a	397.7 a	5.6 a	2.3 b
Cycle 3	62.7 a	696.5 b	6.4 a	5.3 b

*Means in the column marked by the same letters are not significant at the α=0.05

It must be stressed that an essential effect on plant growth was exerted by the climatic conditions and the term of plantation (Tables 1-2). The highest total leaf blade surface area was found in plants planted in 2003 (932.9 cm^2) while in the vegetation season of 2004, it was significantly smaller and, depending on the plantation term, it varied between 307.7 cm^2 (in plants planted in spring) and 696.5 cm^2 (in plants planted in August).

Table 2. Effect of locality on the growth of strawberries in three cycles (in the vegetation terms 2003 – 2004)

Planting cycle	Combinatons	Mean leaf blade surface, cm^2	Total leaf blade surface,cm^2	Root mass, g	Root neck mass, g
Cycle 1	1	80.77 d-f	575.9 b-e	4.99 b-d	9.27 b-d
	2	61.08 bc	748.4 d-g	6.62 d-f	13.50 de
	3	77.80 c-f	859.7 fg	8.25 ef	18.18 e
	4	83.03 ef	832.5 e-g	7.34 d-f	13.65 de
	5	104.83 g	1647.7 h	9.10 f	23.56 f
Mean		81.5 b	932.9 c	7.3 c	15.6 b
Cycle 2	1	35.43 a	277.5 a	1.72 a	3.41 a
	2	53.54 b	374.5 a-c	3.39 a-c	4.68 a-c
	3	64.76 b-e	530.4 a-d	2.96 ab	9.54 cd
	4	60.03 bc	340.7 ab	1.62 a	3.93 ab
	5	72.66 b-f	465.2 a-c	2.06 a	6.48 a-c
Mean		57.3 a	397.7 a	2.3 a	5.6 a
Cycle 3	1	55.72 b	754.3 d-g	5.42 b-d	5.37 a-c
	2	55.81 b	585.9 b-e	6.88 d-f	8.52 a-d
	3	54.11 b	645.9 c-g	4.90 b-d	6.02 a-c
	4	62.18 b-d	596.1 b-f	3.38 a-c	3.37 a
	5	85.84 f	900.2 g	5.88 c-e	8.50 a-d
Mean		62.7 a	696.5 b	5.30 b	6.40 a

*Means in the column marked by the same letters are not significant at the α=0.05

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Literature data indicate that also the system of soil maintenance in the orchard exerts an effect on the condition of soil environment and thereby on the plant growth which due to a higher humus content, is better in the belts of turf than in the belts of herbicide fallow (Akophyne and Aretisyan, 1990; Damżal *et al.*, 1993). In the here presentstudy, no significant statistical differences were found in the growth of the above ground strawberry plant parts grown in the soil from belts of herbicide fallow and in soil from turf belts. However, one can notice similar tendencies to a growth improvement of plants planted in the soil originating from old turf belts. Also the application of a four-year break in apple-trees growing had no significant effect on the growth improvement of strawberries expressed by the leaf blade surface area. It agrees with the earlier study-results of Pacholak and Zydlik (2004).

The basic task of the root system to supply the plant with water and mineral components depends on the soil. The present studies have confirmed the significant effect of soil locality on the growth of the root system expressed by its mass which, independent of the growing cycle, was the lowest in plants grown in the soil of an orchard established in rows of old trees and it amounted to 6.0 g. The greatest root mass (12.8 g) was shown by strawberries grown in the soil of an orchard established on a new ground (Tables 1-2). It has to be stressed that strawberries grown in soil from orchard established on belt of turf in an old orchard had a significantly higher mass of the root system in comparison with other localities after replantation. The application of a 4-year break in the culture did not increase significantly the root mass. Rusell (1958) calls attention to the fact that the growth rate of roots and their condition depend among others on the amount of carbohydrates transferred to the root system by the aboveground plant parts. The existence of such correlation has bean confirmed also by our studies.

Next to the root mass, also the mass of the root neck is an important parameter of strawberry growth. The root neck mass was the lowest in strawberries grown in soil from the orchard established in rows old trees and it amounted to 4.0 g: on the other hand, the highest root neck mass was in the plants planted in the soil originating from orchard established on a new ground and in soil from the belts of old herbicide fallow showing the values of 5.7 g and 5.6 g respectively (Tables 1-2). Similar results were obtained earlier by Pacholak and Zydlik (2004). Similarly as in the case of the growth of aboveground plant parts, significant differentiation was found in the growth of the underground plant parts depending on the plantation term of strawberries. The strongest growth expressed by root mass and root neck mass was found in the plants planted in spring 2003. In the vegetation season 2004, independent of plantation term, the plant growth was significantly poorer. The results of studies carried out in the vegetation seasons 2003 and 2004 confirm that the soil originating from different localities of the replanted apple-tree orchard exerted a significant effect on the growth and development of strawberries.

Conclusions

Strawberry growing in rhizoboxes showed a differentiated effect of the locality on their growth measured by leaf blade surface area and by the masses of roots and root necks.

Apple-trees grown for many years in the same locality significantly decreased strawberry growth expressed by the total leaf blade surface area and by the mass of root and root necks.

Strawberry reacts strongly to soil fatigue and it can be a good plant for testing fatigue occurrence in the orchard because strawberries grown in a new ground had the best growth conditions.

References

1. Akophyne A. and Avetisyan M.Zh. (1990) Effect of successive application of simazine and dalapon on the biological actiyity of orchard soils. Biologicheskii Zhurnal Armenii, 43, 12,1025-1027
2. Constante J.F., Autio W.R. and Berkett L.P. (1991) Controlling apple replant disease in 'Mclntosh' apple replant on various rootstock. HortScience, 26 (5), 604.
3. Domżal H., Flis-Bujak M., Baran S. and Żukowska G. (1993) Wpływ użytkowania sadowniczego na materię organiczną gleby wytworzonej z utworów pyłowych. Zeszyty Postępu Nauk Rolniczych, Z. 411,91-95.
4. Hoestra (1994) Ecology and pathology of replant problems. Acta Horticulture, 363, 1-10.
5. Kozanecka T. and Kępka M. (1996) Wpływ czynników agro-ekologicznych na właściwości fizyczne gleby w sadzie jabłoniowym. Roczniki Gleboznawcze, T. XLVII Suplement, 23-30.
6. Listowski A. (1970) O rozwoju roślin. Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa.
7. Pachołak E. (1997) Zmęczenie gleby, groźne zjawisko replantowanych sadów. Seminarium Sadownicze Przybroda`97, 31-36.

8. Pachołak E. and Zydlik Z. (2004) Effect of locality on the growth of strawberries in rhizoboxes. Sodininkyste ir Daržininkyste, 23 (2), 388-394.
9. Rusell (1958) Warunki glebowe a wzrost roślin. Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa.

PERFORMANCE OF 'RUBIN' APPLE TREES ON NINETEEN ROOTSTOCKS AFTER FOUR YEARS
ĀBEĻU ŠĶIRNES 'RUBIN' IZVĒRTĒJUMS UZ 19 POTCELMIEM ČETRUS GADUS PĒC STĀDĪŠANAS

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Kopsavilkums

Izmēģinājums tika ierīkots auglīgās aluviālās augsnēs Varšavā, 2001. gadā. Pēc četriem gadiem izvērtējot koku izmēru, kurš izteikts stumbra šķērsgriezuma laukumā, mazākais bija uz Nr. 629 un J-TE-G, tad secīgi pieaugošā kārtībā No 280, PB-4, M. 27, P 59, P 22, No. 387, P 64, P 63, P 65, Unima, P 16 un B 146. Lieli koki bija uz P 66 un B 491, bet vislielākie - uz Arm 18, P 62 un M.9 EMLA. Augstākā kumulatīvā raža 2002. – 2004. gados bija uz P 63, P 65, P 16, P 66, B 491, Arm 18, M.9 EMLA un P 22; kokiem uz P 62, P 59, Unima, No. 387, B 146 un P 64 bija zemas ražas; bet uz PB-4, No. 280, M.27, J-TE-G and No. 629 bija viszemākās ražas. Augstākais ražošanas efektivitātes koeficients (kumulatīvā raža / stumbra šķērsgriezuma laukums) pēc 4. gada bija uz P 63, P 65, P 59, P 22 un P 16, zemākais uz Arm 18, M.9 EMLA and P 62.

Abstract

The trial was established on a fertile alluvial soil at Warsaw-Wilanów, Central Poland, in spring 2001. After four years, tree size, expressed as TCSA, was the smallest on No. 629 and J-TE-G, and then, in increasing order, on No. 280, PB-4, M.27, P 59, P 22, No. 387, P 64, P 63, P 65, Unima, P 16 and B 146; still larger were trees on P 66 and B 491, whereas those on Arm 18, P 62 and M.9 EMLA were the largest. Cumulative yield per tree for the 2002-2004 period was highest on P 63, P 65, P 16, P 66, B 491, Arm 18, M.9 EMLA and P 22; trees on P 62, P 59, Unima, No. 387, B 146 and P 64 gave lower yields, while yields of those on PB-4, No. 280, M.27, J-TE-G and No. 629 were the lowest. The cropping efficiency coefficient, calculated as a ratio of cumulative yield to the TCSA after the 4th year, was highest on P 63, P 65, P 59, P 22 and P 16, and lowest on Arm 18, M.9 EMLA and P 62. The highest yield per ha was obtained from trees on p 63, P 65, P 22 and P 16.

Keywords: apple, rootstock, tree vigour, yield, cropping efficiency, fruit size

Introduction

The Czech apple cultivar Rubin has gained some interest in Poland due to the exceptionally high dessert quality of its fruit (Kruczyńska, 2002). It is considered as one of the tastiest apples in Central Europe. Unfortunately its precocity, as well as its yielding potential, were estimated as rather low (Ugolik *et al*., 2001). Selecting appropriate rootstocks may solve these problems.

Apple growing in Europe is dominated by the old but superb rootstock M.9 (Wertheim, 1998). However, , when grown on very rich soils, trees of vigorous cultivars on M.9 develop too large canopies. Searching for rootstocks inducing weaker vigour is thus necessary (Sadowski, 1999). Testing new rootstocks, bred in different countries, gives an opportunity to select more valuable clones for specific cultivars and specific site conditions. In general, a good rootstock should ensure small tree stature, thus allowing an efficient transformation of solar energy into fruit (Cummins and Aldwinckle, 1983). Other essential features of rootstocks are an ability to induce early, high and regular cropping and create a positive influence on fruit quality (Zagaja *et al*., 1989; Jakubowski, 2004). High winter hardiness is also a desirable characteristic in Poland. Before a rootstock is officially recommended, it should be carefully evaluated, in comparison to the standard rootstocks, under orchard conditions (Jadczuk and Wlosek-Stangret 1999, Czynczyk *et al*. 2001; Jakubowski, 2004).

For Polish climate and soils, native rootstocks or those obtained in countries with similar natural conditions may be the most suitable. Of special interest are rootstocks coming from the breeding programme carried out at the Research Institute of Pomology and Floriculture at

Skierniewice (Zagaja *et al*., 1988). Some interesting rootstocks have been also selected in other countries of Central and Eastern Europe (Samuś, 1996). They apparently need a more careful evaluation.

The objective of this study is to test the suitability of different rootstocks for the vigorous apple cultivar Rubin, grown on a fertile soil, with special reference to the new rootstocks bred in Poland. Preliminary results have been presented in the paper of Piestrzeniewicz and Sadowski (2005).

Materials and Methods

The trial was set up on a silty loam alluvial soil in the Experimental Orchard of the Warsaw Agricultural University at Warsaw-Wilanów, Central Poland, in spring 2001. Nineteen rootstocks were compared: the Armenian rootstock Arm 18, the Belorussian PB-4, the Czech J-TE-G and Unima, Polish rootstocks P 16, P 22, P 59, P 62, P 63, P 64, P 65, P 66, No. 280, No. 387, and No. 629, the Russian B 146 and B 491 as well as the standard English rootstocks M.9 EMLA and M.27.

Maiden trees of Rubin cultivar were planted in rows spaced 3 m apart. The in-row spacing depended on expected tree vigour on a particular rootstock. It was 1 m for trees classified as very dwarf (on J-TE-G, M.27, P 22, P 59, P 63, P 64, P 65 and PB-4), 1.2 m for those assumed as intermediate between very dwarf and dwarf (on B 491, No. 280, No. 387 and No. 629, P 16 and Unima), and 1.5 m for those considered as dwarf (on Arm 18, B 146, M.9 EMLA, P 62 and P 66).

The experiment was established in a randomised block design with four replications and 5 trees per plot, with the exception of the No. 629, which was represented by 3 trees per plot. Trees were planted with the bud union at 5 cm above ground level and trained as standard spindle, with trunks ca 70 cm high. Every year, from mid-May to the beginning of June, all newly developing shoots were successively cut back to about half of their length, when they reached ca 25 cm, to stimulate branching. In 2001 all trees were deblossomed. In 2002, 2003 and 2004 fruitlets were hand thinned after June drop. In 2004 chemical thinning with Pomonit R10 (NAA) was also applied.

In autumn 2004 trunk diameter at 30 cm was measured and trunk cross-sectional area (TCSA) calculated. Yield data were recorded in successive years (2002- 2004) and number of root suckers per tree was counted in May 2005. Data were elaborated by analysis of variance, with mean separation by Newman-Keuls test, at α=0.05.

Results

The TCSA in autumn 2004 served as a measure of tree size after 4 years in the orchard and reflected tree vigour induced by a rootstock. The least vigorous appeared trees on No. 629, followed by those on J-TE-G (Table 1). Trees on the Belorussian PB-4 and on Polish rootstocks No. 280, No. 387, P 59 presented vigour roughly comparable to those on the standard very dwarfing M.27. The rootstock P 22 and the newest Polish clones, No. 387, P 64, P 63 and P 65, induced some more vigour. The size of trees on Unima, P 16, B 146 and P 66 was quite similar, being somewhat smaller than that of the standard dwarfing M.9 EMLA. Growth of trees on B 491, Arm 18, P 62 and M.9 EMLA was the most vigorous, as showen by the TCSA 4-5 times larger than that of trees on No. 629.

In-row spacing, assigned for trees on a particular rootstock was not always right, as the real size of trees sometimes appeared different from the expected. Trees on No. 629 and No. 280 were planted at 1.2 m in row (2778 trees per ha), but it was wrong, as they showed extremely low vigour and have not filled the assigned space after four years. In contrast, trees on new rootstocks P 63 and P 65 were planted too densely (at 1 m in row, 3333 trees per ha). They grew more vigorously than it was expected and after four years got overcrowded. The same was true for trees on B 491, which were spaced at 1.2 m, but should rather have the 1.5-m spacing. Overcrowding was also observed in trees on M.9 EMLA and P 62, though they were planted at maximum planned spacing (1.5 m).

The highest yield in the fourth year after planting (2004) was obtained from trees on Arm 18 and M.9 EMLA – ca. 20-21 kg tree^{-1}, and the lowest on No. 629, J-TE-G and PB-4 – less than 10 kg per tree. The highest cumulative yield per tree for three bearing years (2002-2004), exceeding 25 kg per tree, was on P 63, P 65, P 16 and P 66. Trees on B 491, Arm 18, M.9 EMLA, P 22 and P 62 produced also rather high yields, ranging from 23.6 to 20.2 kg tree^{-1}. The lowest were cumulative yields were from trees on No. 280, M.27, J-TE-G and No. 629 (12.8 to 8.6 kg tree^{-1}).

The yield calculated per ha was a function of yield per tree and of the number of trees per ha; the latter depended, of course, on the in-row spacing. In 2004 most of the tested rootstocks induced yields higher than 40 t ha^{-1}. The most productive were trees on P 65, P 63 and B 491, with yields over 50 t ha^{-1}. Cumulative yield per hectare was the highest for trees on P 63 and P 65. A high cumulative production (over 60 t ha^{-1}) was also obtained from trees on P 22, P 16, B 491 and P 59. The lowest yields for the three-year period of bearing were obtained from small trees, grown on the rootstocks No. 629 and J-TE-G, but also from trees on B 146.

Table 1. Indices of vigour and cropping of 'Rubin' trees on different rootstocks (listed from the top to the bottom in order of increasing TCSA in autumn 2004)

Rootstock	TCSA autumn 2004, cm^2	Yield, kg tree^{-1}		Number of trees per ha	Yield, t ha^{-1}		CEC [\1], kg cm^{-2}	Mean fruit mass 2004, g	No. of suckers per tree
		2004	2002-2004		2004	2002-2004			
No. 629	4.8 f	5.5 h	8.6 i	2778	15.3 f	23.8 f	1.80 a-d	217	0.0 d
J-TE-G	6.2 ef	7.8 gh	11.0 hi	3333	26.0 e	36.8 e	1.77 a-d	239	0.1 d
No. 280	8.4 def	11.6 d-g	14.7 f-h	2778	32.1 c-e	40.9 e	1.76 a-d	265	2.8 b
PB-4	8.5 def	9.2 f-h	15.3 e-h	3333	30.5 de	51.2 c-e	1.82 a-d	238	0.2 d
M.27	8.6 def	10.3 e-h	12.8 g-i	3333	34.4 c-e	42.8 e	1.46 b-f	264	0.0 d
P 59	9.2 cde	10.7 e-h	18.9 c-g	3333	35.7 b-e	63.1 b-e	2.06 ab	255	0.7 cd
P 22	11.0 cde	12.5 c-g	22.0 a-e	3333	41.7 a-e	73.2 b	2.00 a-c	235	1.2 b-d
No. 387	11.3 cde	13.9 b-f	17.8 d-g	2778	38.7 a-e	49.6 c-e	1.61 b-e	251	0.2 d
P 64	11.4 cd	14.3 b-f	17.1 d-g	3333	47.7 a-d	57.1 b-f	1.50 b-f	277	0.1 d
P 63	12.2 bcd	16.7 a-e	27.5 a	3333	55.5 a	91.7 a	2.26 a	252	0.0 d
P 65	12.7 bcd	16.6 a-e	26.0 ab	3333	55.5 a	86.5 a	2.08 ab	243	0.1 d
Unima	13.6 bcd	15.1 a-f	18.7 c-g	2778	41.8 a-e	51.9 c-e	1.41 b-f	271	0.5 d
P 16	13.8 bcd	17.6 a-d	25.7 ab	2778	49.0 a-c	71.4 b	2.00 a-c	260	1.5 b-d
B 146	14.1 bc	14.1 b-f	17.3 d-g	2778	31.3 c-e	38.5 e	1.23 d-f	240	1.6 b-d
P 66	15.8 b	19.2 ab	25.3 abc	2222	42.7 a-e	56.3 b-f	1.60 b-e	268	0.1 d
B 491	17.8 a	18.9 abc	23.6 a-d	2778	52.4 ab	65.6 bc	1.34 c-f	256	2.2 bc
Arm 18	22.4 a	21.2 a	22.8 a-d	2222	47.2 a-d	51.2 c-e	1.04 e-f	274	8.4 a
P 62	23.7 a	18.7 abc	20.2 b-f	2222	41.6 a-e	44.9 de	0.91 f	271	0.4 d
M.9 EMLA	24.0 a	19.8 ab	22.6 a-d	2222	44.0 a-d	50.3 c-e	0.93 f	254	0.0 d

[\1] CEC expressed as a ratio of the yield of three years (2002+2003+2004) to the TCSA in autumn 2004
[\2] Mean separation (within columns) by Newman-Keuls test, at α = 0.05

Cropping efficiency coefficient (CEC), calculated as a ratio of total yield for the three-year period (2002-2004) to the TCSA in autumn 2004, illustrates productivity of trees in relation to their final size. The highest CEC, over 2 kg cm^{-2}, was noted for trees on P 63, P 65, P 59, P 16, and P 22. The lowest relative productivity was demonstrated by trees grown on the most vigorous rootstocks, M.9 EMLA, P 62 and Arm 18; their CEC reached only about 1 kg cm^{-2}.

Fruits of the 2004 crop were large, in general, and were not markedly influenced by rootstock. The smallest fruits were from trees on No. 629, albeit their mean mass was also over 200 g.

Rootstocks No. 629, P 63, M.9 EMLA and M.27 did not produce any suckers. Few suckers were recorded in most of other rootstocks. The rootstock Arm 18 suckered intensely, producing over 8 root sprouts per tree. A considerable suckering was also noted from P 16, B 146 and B 491.

Discussion

Most of the rootstocks tested with Rubin scion exhibited a lower vigour than that of the standard M.9 EMLA. Some of them, like No. 629, showed an extremely low vigour, and might be classified as “ultra dwarf” (more dwarf than M.27), according to the terminology suggested by Zagaja *et al*. (1989) and Jakubowski (2004).

Previous results of the same experiment (Piestrzeniewicz and Sadowski 2004) have shown that ’Rubin’ was the most precocious in bearing when grown on the rootstocks P 63, P 22, P 65, P 59 or P 16. The recent results have confirmed that these rootstocks induced high productivity. When considering cropping efficiency coefficient (CEC) for a period of three years of bearing, the most productive were trees on rootstocks intermediate in vigour between very dwarfing and on typical dwarfing, namely on P 63, P 65 and P 16, but also on P 59 and P 22, classified as very dwarfing.

The best indicator of rootstock suitability is “commercial productivity” induced by it, i.e. yield per unit area, expressed in tons per ha (Jadczuk and Wlosek-Stangret, 1999). However, it is not easy to assign o proper area for a tree, as tree vigour is not easy to predict. Spacing applied for trees on some rootstocks in this study was overestimated or underestimated. Too dense planting of trees on certain rootstocks may cause a necessity of severe pruning and then of decline of productivity in the future.

A tendency of some rootstocks to reduce fruit size was reported by Zagaja *et al.* (1989). In our study, ultra dwarfing No. 629 reduced mean fruit mass, but in the case of the large-fruited 'Rubin' it may have little importance, as in the case of 'Jonagold' (Jakubowski, 2004).

The ability of a rootstock to produce root suckers may influence its acceptability by nurserymen and growers, and, to some extent, is associated with low vigour (Cummins and Aldwinckle, 1983 and Wertheim, 1998). In this experiment some tendency to suckering of P 16 as well as of B 146 and B 491 was noted. This was in line with the reports of Wertheim (1998) and of Sadowski *et al*. (1999). Also an intense suckering of Arm 18 may be considered as a serious disadvantage of this rootstock.

Conclusions

The standard dwarfing rootstock M.9 is too vigorous for vigorous cultivars grown on fertile soils.

The apple cultivar Rubin may be precocious in bearing and highly productive when grown on adequate rootstock of a relatively low vigour P 16, P 63, P 65, P 22 and P 59 may be promising rootstocks for 'Rubin' grown in a fertile soil.

References

1. Cummins J.N. and Aldwinckle H.S. (1983) Breeding apple rootstocks. Plant Breeding Rev., 1, 294-394.
2. Czynczyk A., Bielicki P. and Bartosiewicz B. (2001) Testing new dwarfing apple rootstocks from Polish and foreign breeding programmes. Acta Hort., 557, 83-89.
3. Jadczuk E. and Wlosek-Stangret C.R. (1999) Cropping and fruit quality of Jonagold apple trees depending on rootstock. In: A. Sadowski (ed.) Apple Rootstocks For Intensive Orchards. Apple Rootstocks for Intensive Orchards, Proc. Intern. Seminar, Warsaw Agric. Univ., Poland, 45- 46.
4. Jakubowski T. (2004) The influence of rootstock clones on yield, fruit size and colouring of apples of the cultivar 'Jonagold'. Acta Hort., 658, 349-351.
5. Jakubowski T. and Zagaja S.W. (2000) 45 years of apple rootstocks breeding in Poland. Acta Hort., 538, 723-727.
6. Kruczyńska D. (2002). Jabłonie – nowe odmiany, Hortpress, Warszawa, Poland, 150.
7. Piestrzeniewicz C. and Sadowski A. (2005) Early orchard performance of 'Rubin' apple on nineteen rootstocks. Acta Hort. [in press].
8. Sadowski A., Pająk T. and Półtorak W. (1999) Growth and early yield of 'Jonagold', 'Holiday' and 'Fiesta' apple trees on different rootstocks. In: A. Sadowski (ed.) Apple Rootstocks For Intensive Orchards. Apple Rootstocks for Intensive Orchards, Proc. Intern. Seminar, Warsaw Agric. Univ., Poland, 91- 92.
9. Samuś W.A. (1996) Obiecujące podkładki wegetatywne dla jabłoni. Szkółkarstwo, 3, 6-7.
10. Ugolik M., Zydlik Z. and Kantorowicz-Bąk M. (2001) Wzrost, plonowanie i jakość owoców jabłoni z grupy ‘Golden Delicious’. Zesz. Nauk. Instytutu Sadownictwa i Kwiaciarstwa w Skierniewicach, 9, 117-122.
11. Wertheim S.J. (1998) Rootstock guide: apple, pear, cherry, European plum. Fruit Research Station Wilhelminadorp Bulletin, Netherlands.
12. Zagaja S.W., Czynczyk A., Jakubowski T. and Omiecińska B. (1988) Breeding and evaluating apple rootstocks for Northern Europe. HortScience, 23, 109-112.

13. Zagaja S.W., Jakubowski T., Piekło A. and Przybyła A. (1989) Preliminary evaluation of new clones of apple rootstocks. Fruit Sci. Rep., 16, 205-213.

GROWTH AND BEARING OF 'JONAGOLD' APPLE TREES AS AFFECTED BY ROOTSTOCK AND TYPE OF NURSERY TREES USED FOsR PLANTING
'JONAGOLD' ĀBEĻU AUGUMA UN RAŽĪBAS IZVĒRTĒJUMS PĒC POTCELMA UN STĀDĪTĀ KOKA TIPA

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Kopsavilkums

Izmēģinājums tika ierīkots Polijas centrālajā daļā, Vilanovā. Desmit gados intensīvāk koki auga uz M.26 un zemākā auguma koki bija uz P 22. Kumulatīvā raža no koka (1994-2001) bija aptuveni proporcionāla koku augstumam, bet raža ha^{-1} bija atkarīga no stādījuma biezības. Augstākā ražošanas intensitāte bija kokiem uz P 22 un zemākā uz M.26 potcelma. Vismazākie augļi bija uz P 22. Koka tipa ietekme uz koka augumu bija atkarīga no stādīšanas laika. Viengadīgi koki, kuri stādīti 1991. gada pavasarī sasniedza augstāko augumu, bet tāda paša tipa koki stādīti gadu vēlāk bija zemākie. Augstākā raža iegūta no viengadīgiem stādiem ar sasteigtajiem dzinumiem, kuri stādīti 1991. gada pavasarī vai no divgadīgiem kokiem stādītiem 1992. gada pavasarī. Netika konstatētas būtiskas atšķirības augļa masā un izskatā starp stādīto koku tipiem.

Abstract

The experiment was carried out in Warsaw-Wilanów, Central Poland. The growth of trees for the ten-year period was the most intense on M.26 and the least on P 22. Cumulative yield per tree (1994-2001) was roughly proportional to the size of trees on used rootstocks and yield per ha was related to the planting density. Cropping efficiency was the highest for trees on P 22 and the lowest on M.26. On the average, fruits were smallest from trees on P 22. The effect of tree type on vigour was related to the time of planting in the orchard. One-year-old maidens planted in spring 1991 reached the largest size, while trees of the same type planted one year later – the smallest. Higher yield, both per tree and per area unit, was obtained from the one-year-old, feathered maidens, planted in spring 1991 or from two-year-old trees left for the 3rd year in the nursery without heading back, and planted in spring 1992 than from two-year-old trees trained as “knip-boom”, planted in 1992, or from one-year-old maidens, planted in 1992. No significant differences in mean fruit mass due to the tree type were noted. Neither rootstock nor the tree type had any effect on fruit firmness.

Key words: apple, rootstock, tree-type, growth, yield, fruit-quality

Introduction

Use of appropriate rootstock is the basic method for efficient and long-term control of vigorously growing apple cultivars, like 'Jonagold' (Skrzyński and Poniedziałek, 1999). In an intensive planting system, production of apple fruit orchard is successful when dwarfing rootstocks have been used (Crowe and Embree, 1987). Wertheim (1981) underlined that trees on dwarfing rootstocks provide early and regular bearing and high fruit quality. Jadczuk (1997 and 2000); Sadowski *et al.* (2000) and Słowiński and Sadowski (2000) presented evidence that growth intensity, easiness of crown formation as well as early and high cropping are affected by the type and quality of trees used for planting. In this paper results of ten-year trial on the effect of rootstock and of tree type used for planting are presented

Materials and Methods

The experiment was carried out in the Wilanów Experimental Orchard of the Warsaw Agricultural University, located in the post-glacial valley of Vistula river, in Central Poland. The soil was a silty loam, slightly acid, alluvial soil, rich in humus (ca 2-2.5%) and low in K. 'Jonagold' trees on P 22, P 2 and M.26 were planted as four types: (1) one-year-old, feathered maidens, planted in spring 1991; (2) two-year-old trees with a two-year old crown – maidens left for the 3rd year in the nursery without heading back (two-year-olds I), planted in spring 1992; (3) two-year-old trees –

headed back in the 3rd year of nursery and trained as "knip-boom" (two-year-olds II), planted in 1992 and (4) one-year-old maidens, planted in 1992. Trees on P 2 and M.26 were spaced at 4×2.4 m and those on P 22 at 4×1.2 m. Trees were trained as slender spindle. Herbicide strips (1 m) were maintained along tree rows and permanent sward in alleyways. The trial was established in a split block factorial randomised design with 6 replications having two (on M.26 and P 2) or four (on P 22) trees per plot.

Trunk diameter was measured and the increment of trunk cross-sectional area (TCSA) calculated. Yield from each plot was recorded and then calculated per tree and per hectare. The crop efficiency coefficient (CEC) was calculated as a ratio of yield to the TCSA. Mean fruit mass and firmness was determined on representative samples of 30 fruits per plot. Data on tree growth and yield were elaborated by analysis of variance. Mean separation was performed using the Newman-Keuls test, at $\alpha=0.05$.

Results

The growth of trees was significantly affected by rootstock and tree type (Table 1). The initial trunk cross sectional area (in spring 1992), served as an indicator of tree vigour in the nursery. It was the smallest on superdwarfing P 22 and significantly larger on semidwarfing P 2 or M.26. After ten years in the orchard (1992-2001) tree vigour, expressed by the increase of TCSA, was the smallest on P 22, somewhat larger on P 2 and the largest on M.26. When trees on M.26 were considered as a standard (100%), the relative vigour of trees on P 22 was 31% and on P 2 – 79%. In spring 1992 one-year-old feathered maidens trees planted in the orchard in spring 1991 had significantly higher TCSA than trees, which stayed for the year 1991 in the nursery and were just planted in the orchard. No significant differences in the TCSA of different types of trees planted in spring 1992 were noted. The increment of TCSA over the whole period of study was the largest in trees planted as one-year-old maidens in autumn 1991. When this was considered as standard (100%), trees of the same type planted one year later had only 67 % of it. The ten-year study has not shown any significant differences in vigour of two-year-old trees with a two-year old crown, i.e. maidens left for the 3rd year in the nursery without heading back, and two-year-old trees headed back in the 3rd year of nursery and trained as "knip-boom", both planted in 1992.

Table 1. Initial trunk cross-sectional area (TCSA) and its increment for three, five, seven and ten years, cm^2

Factor	Initial TCSA spring 1992	Increment of TCSA for successive periods			
		1992-94	1992-96	1992-98	1992-2001
Effect of rootstock; mean of different tree types:					
P 22	1.4 b[1]	6.5 c	12.6 c	15.3 c	25.8 c
P 2	1.9 a	11.4 b	27.7 b	36.4 b	66.1 b
M.26	2.1 a	13.6 a	31.7 a	42.5 a	83.2 a
Effect of tree type; mean of different rootstocks:					
one-year-olds, planted in 1991	4.0 a[1]	13.8 a	29.9 a	38.6 a	68.6 a
two-year-olds I, planted in 1992	1.1 b	10.6 b	24.5 b	32.5 b	61.7 ab
two-year-olds II, planted in 1992	1.1 b	9.4 bc	22.7 b	29.5 bc	57.2 b
one-year-olds, planted in 1992	1.0 b	8.1 c	18.8 c	25.0 c	46.0 c

[1] Mean separation by Newman-Keuls test, at $\alpha=0.05$.

The effect of rootstock and tree type on yield indices was also noted (Table 2). 'Jonagold' trees started to bear fruit in the third year after planting (1994). The highest first yield (15.5 $kg \cdot tree^{-1}$) was obtained from trees on M.26, followed by yield of trees on P 2 (12.8 kg), then by those on P 22 (9.5 kg). In the next years the yield (1996) was, in general, related to the size of trees on particular rootstocks. In 1995, due to a weak bloom and unfavorable weather conditions in bloom time, yield was, in general, very low and it has not been considered. Cumulative yield for seven years (1994-2001) was the highest on P 2 and M.26 – on the average twice as high as yield of trees on P 22. The highest yield per hectare was always noted from trees on P 22, except for 1999 and 2000. The highest commercial production, for the period of 7 years of bearing, was obtained from trees on P 22. Trees on P 2 and M.26 showed a significantly lower productivity.

Table 2. Annual yield per tree (kg $tree^{-1}$) and calculated per unit land area ($t \cdot ha^{-1}$) in successive years and total for the whole period of study

Factor	Years							Total yield for 7 years (1994-2001)
	1994	1996	1997	1998	1999	2000	2001	
Effect of rootstock; mean of different tree types:								
Yield per tree								
P 22	9.5 c[1]	14.4 b	8.8 b	15.4 b	15.5 b	23.4 b	31.5 b	118 b
P 2	12.8 b	20.5 a	21.3 a	31.6 a	28.0 a	40.8 a	54.2 a	209 a
M.26	15.5 a	15.7 b	21.7 a	29.4 a	27.1 a	40.2 a	55.2 a	204 a
Yield per hectare								
P 22	20 a	30 a	18 b	28 b	27 a	49 a	65 a	237 a
P 2	13 c	21 b	22 a	33 a	29 a	43 a	56 b	217 b
M.26	16 b	16 c	22 a	31 ab	28 a	42 a	57 b	212 b
Effect of tree type; mean of different rootstocks:								
Yield per tree								
one-year-olds, planted in 1991	18.5 a[1]	18.5 a	19.0 a	28.6 a	23.4 ab	34.6 a	49.8 a	192 a
two-year-olds I, planted in 1992	13.6 b	18.1 a	17.3 a	27.2 a	26.8 a	40.1 a	52.7 a	196 a
two-year-olds II, planted in 1992	10.4 c	15.7 a	17.0 a	24.1 ab	22.2 b	27.4 b	43.7 b	160 b
one-year-olds, planted in 1992	8.0 d	15.2 a	15.8 a	22.0 b	21.6 b	37.0 a	41.7 b	161 b
Yield per hectare								
one-year-olds, planted in 1991	24 a	25 a	23 a	35 a	27 a	43 bc	62 a	239 a
two-year-olds I, planted in 1992	17 b	25 a	21 a	33 a	31 a	52 a	67 a	246 a
two-year-olds II, planted in 1992	14 b	21 b	21 a	29 ab	26 a	36 c	56 a	203 b
one-year-olds, planted in 1992	11 c	20 b	19 a	27 b	26 a	47 ab	54 a	204 b

[1] For explanations see Table 1

Yield of different tree types, expressed either in kg per tree or in tons per hectare, did not differ very much. In the first year of bearing the highest yield was harvested from trees planted one year earlier to the orchard. One-year-old maidens planted in 1992 gave the lowest early yield. Nevertheless, in successive years they gave similar or higher yields as two-year-old "knip-boom" trees planted at the same time. The cumulative yield (1994-2001) was higher from trees planted in 1991 as maidens or from planted in 1992 as two-year-olds with a 2-year-old crown (trained in the nursery without heading back) than from planted in 1992 as two-year-old "knip-boom" trees or as one-year-old maidens.

The cropping efficiency coefficient depended on experimental factors and obviously was related to the tree vigour (Table 3).

Table 3. Cropping efficiency coefficient for the first year of bearing, for the successive biennial periods and for 7 years of bearing, kg cm^{-2}

Factor	1994/ TCSA 1994	1996-97/ TCSA 1996	1998-99/ TCSA 1998	2000-01/ TCSA 2000	1994-2001/ TCSA 2001
Effect of rootstock; mean of different tree types:					
P 22	1.11 a[1]	1.63 a	1.76 a	2.11 a	4.53 a
P 2	0.93 a	1.46 a	1.59 a	1.43 b	3.22 b
M.26	0.95 a	1.16 b	1.31 b	1.16 c	2.56 c
Effect of tree type; mean of different rootstocks:					
one-year-olds, planted in 1991	1.16 a[1]	1.28 b	1.31 b	1.28 c	2.98 c
two-year-olds I, planted in 1992	0.97 b	1.39 ab	1.60 ab	1.64 b	3.47 b
two-year-olds II, planted in 1992	0.94 b	1.34 b	1.46 b	1.31 c	3.01 c
one-year-olds, planted in 1992	0.91 b	1.66 a	1.84 a	2.02 a	4.25 a

[1] For explanations see Table 1

The CEC, expressed as kg of yield per cm^2 of trunk cross-sectional area, calculated after ten growing seasons, was the highest for trees on superdwarfing P 22, significantly lower on P 2 and the lowest on M.26. Concerning tree type, the highest CEC was noted for maiden trees planted in 1992. The smallest values of CEC were found for one-year-old trees planted in 1991and two-year-olds trained as “knip-boom”, planted in 1992.

The highest mean fruit mass was recorded in 2000 – 372 g, on the average of different rootstocks and tree types (Table 4). This was due to low yield caused by spring frost damage. Rootstock significantly affected mean fruit mass. In most years of study 'Jonagold' fruits from trees on P 22 were smaller than fruit from trees on M.26 or P 2. Tree type significantly influenced fruit mass only in the first years and differences were rather small. Neither rootstock nor the tree type had any effect on fruit firmness (Table 5).

Table 4. Mean fruit mass in successive years and average for 7 years of the study, g

Factor	Years							Average (1994-2001)
	1994	1996	1997	1998	1999	2000	2001	
Effect of rootstock; mean of different tree types:								
P 22	140 b[1]	186 b	217 b	190 b	209 b	361 c	226 a	218 b
P 2	150 a	214 a	233 a	209 a	236 a	373 ba	237 a	236 a
M.26	151 a	206 a	237 a	206 a	236 a	384 a	247 a	238 a
Effect of tree type; mean of different rootstocks:								
one-year-olds, planted in 1991	134 b[1]	214 a	241 a	203 a	228 a	380 a	232 a	233 a
two-year-olds I, planted in 1992	150 b	204 b	223 b	197 a	232 a	375 a	240 a	231 a
two-year-olds II, planted in 1992	150 a	195 b	223 b	198 a	229 a	371 a	238 a	229 a
one-year-olds, planted in 1992	154 a	195 b	229 ab	205 a	219 a	364 a	238 a	229 a

[1] For explanations see Table 1

Table 5. Fruit firmness at harvest time in successive years, %

Factor	Years						
	1994	1996	1997	1998	1999	2000	2001
Effect of rootstock; mean of different tree types:							
P 22	6.1 b[1]	6.9 a	7.2 a	6.5 a	7.6 a	7.6 a	6,0 a
P 2	6.3 a	6.8 a	6.9 b	6.1 a	7.4 ab	7.5 a	5,9 a
M.26	5.9 b	6.9 a	6.9 b	6.3 a	7.2 b	7.6 a	5,9 a
Effect of tree type; mean of different rootstocks:							
one-year-olds, planted in 1991	5.9 a	6.8 a	6.8 b	6.2 a	7.4 a	4.5 a	5.9 a
two-year-olds I, planted in 1992	6.1 a	6.8 a	7.0 a	6.5 a	7.4 a	7.6 a	6.1 a
two-year-olds II, planted in 1992	6.1 a	6.9 a	7.0 a	6.2 a	7.4 a	7.7 a	5.9 a
one-year-olds, planted in 1992	6.2 a	6.9 a	7.2 a	6.2 a	7.5 a	7.6 a	5.9 a

[1] For explanations see Table 1

Discussion

The results of this study confirmed the opinion of Skrzyński and Poniedziałek (1999); Sadowski *et al*. (1999) and Jadczuk (2000) that using a dwarfing rootstock for vigorous cultivar, like Jonagold, is the most efficient method for obtaining early and regular bearing as well for a long-term control of tree vigour. According to Van Oosten (1986), rootstock effect on growth in the orchard may be different than in the nursery. In our study, the initial tree growth was also similar and the differences in vigour increased with tree age. Jadczuk and Bogdanowicz (1995) and Jadczuk (1997) summarising the effects of rootstock on growth and cropping of this cultivar trees in the first years in the orchard reported that trees on P 22 were less vigorous but gave earlier and higher yields. This tendency was apparent during ten years of tree growth. Trees on this rootstock were the smallest and hence gave the lowest yield per tree; however they showed the highest productivity; expressed as the highest yield per hectare and the highest cropping efficiency coefficient, compared to those on P 2 and M.26. The same was reported by Skrzyński and Poniedziałek (1999); Jadczuk (2000) and

Napiórkowski *et al*. (2002). The long-term study has shown that 'Jonagold' apples from trees on P 22 were the smallest. This is in accordance with the opinion of Ystaas and Frøynes (1993); Jadczuk and Wlosek Stangret (1999) and Pietranek *et al*. (2000).

The results obtained confirmed that along with the use of dwarfing rootstock, quality of nursery stock used for planting is a major factor determining early bearing and adequate tree growth (Jadczuk and Bogdanowicz, 1995; Sadowski *et al*., 1997; Jadczuk, 2000 and Sadowski *at al*., 2000). In general, growth, yielding and fruit quality of 'Jonagold' apple trees were affected by planting stock. Comparing one-year-old feathered maidens planted in spring 1991 and in spring 1992, it was found that trees planted one year earlier were the largest and the most productive. The differences were also noted between the trees planted in the same year (1992). In the first years of in the orchard the two-year-old trees apparently surpass the one-year-old maidens in cropping (Jadczuk and Bogdanowicz, 1995 and Jadczuk, 1997; Sadowski *et al*., 2000). Later the differences due to the age of planted trees were not so evident but differences due to the tree type were more accentuated. Basing on the results of seven years of bearing the two-year-old trees with a two-year old crown (maidens left for the 3^{rd} year in the nursery without heading back), planted in spring 1992, gave the highest yield per tree and per hectare; cropping of trees trained in the 3^{rd} year of nursery as “knip-boom” was only slightly lower. It is in line with previous reports of Jadczuk (2000) and Napiórkowski *et al*. (2002). The used tree types have no significantly effect on fruit quality, as it has been reported by Oosten and Westerlaken (1981).

Conclusions

Rootstock and type of nursery trees used for planting significantly affect the growth of 'Jonagold' apple trees.

For intensive orchard and very vigorous cultivars, like 'Jonagold', planted on a fertile soil, P 22 may provide a for optimal tree vigour.

Planting one-year-old maidens one year earlier may provide a similar effect, in terms of tree growth and cropping, as leaving the same trees in the nursery and planting them one year later.

In general, two-year-old trees should be preferred for the establishment of intensive apple orchards.

References

1. Crowe A. D. and Embree C. G. (1987) Recent advances in rootstock research at Kentville. Compact Fruit Tree, 20, 716-724.
2. Jadczuk E. and Bogdanowicz N. (1995) Wstępne wyniki badań nad wpływem podkładki i rodzaju sadzonych drzewek odmiany 'Jonagold'. In: «Postęp w Intensyfikacji Upraw Sadowniczych». I Ogólnopolskie Seminarium Pracowników Katedr Sadownictwa, Poznań, Poland, 69 -75.
3. Jadczuk E. (1997) Growth and cropping of 'Jonagold' apple trees depending on the type of nursery trees used for planting. In: Kviklys D., Cironkiené Z., Sabauliaskiené V. (eds). Modern Orchards: Achievements and Tendencies. Collection of Scientific Articles. Lithuanian Institute of Horticulture, Babtai, Lithuania, 42-46.
4. Jadczuk E. and Wlosek Stangret C. R. (1999) Cropping and fruit quality of 'Jonagold' apples trees depending on rootstock. In: Sadowski A. (ed). Apple Rootstocks for Intensive Orchards, Proc. Intern. Seminar, Warsaw Agric. Univ., Poland, 45-46.
5. Jadczuk E. (2000) Growth and bearing of 'Jonagold' apple trees on eight rootstocks. Acta Hort., 517, 175-182.
6. Jadczuk E. (2000) Wzrost i owocowanie jabłoni w zależności od podkładki i rodzaju sadzonych drzewek. Rocz. AR Poznań, 323. (II), 87-91.
7. Napiórkowski W., Jadczuk E. and Pietranek A. (2002). Wpływ rodzaju sadzonych drzewek na wzrost i plonowanie drzew odmiany Jonagold. Zesz. Nauk. ISK, 10, 49-51.
8. Oosten G. and Westerlaken J. (1981) Hoe belangrijk is goed plantmaterial? Fruitteelt, 71, 1304-1306.
9. Oosten van H.J. (1986) Intraclonal variation in M.9 rootstock and its effects on nursery and orchard performance. Acta Hort., 160, 67-77.

10. Pietranek A., Jadczuk E. and Wlosek Stangret C. R. (2000) Effect of rootstocks on growth and fruiting of 'Jonagold' apple trees. In: Kaufmane E., Libek A. (eds), Proc. Intern. Conf. Fruit Production and Fruit Breeding, Tartu University Press, Estonia, 76-79.
11. Sadowski, A., Maciejczak G. and Wrona D. (1997) Growth and early bearing of 'Šampion' apple trees depending on rootstock and tree quality. In: Kviklys D., Cironkiené Z., Sabauliaskiené V. (eds). Modern Orchards: Achievements and Tendencies. Collection of Scientific Articles. Lithuanian Institute of Horticulture, Babtai, Lithuania, 28-34.
12. Sadowski, A., Pająk, T. and Półtorak, W. (1999) Growth and early yield of 'Jonagold', 'Holiday' and 'Fiesta' apple trees on different rootstocks. In: Sadowski A. (ed). Apple Rootstocks for Intensive Orchards, Proc. Intern. Seminar, Warsaw Agric. Univ., Poland, 91-92.
13. Sadowski, A., Słowiński A., Dominiak R. and Kuras M. (2000) Quality of planting stock and productivity of apple trees. In: Kaufmane E., Libek A. (eds), Proc. Intern. Conf. Fruit Production and Fruit Breeding, Tartu University Press, Estonia, 37-41.
14. Słowiński A. and Sadowski A. (2000) Wzrost i owocowanie jabłoni 'Elstar' w zależności od rodzaju drzewek użytych do założenia sadu. Zesz. Nauk. ISK, 8, 60-66.
15. Skrzyński J. and Poniedziałek W. (1999) Growth and cropping of 'Jonagold' apple trees on six different rootstocks: M.9, M.26, P 2, P 14, P 22 and P 60. In: Sadowski A. (ed). Apple Rootstocks for Intensive Orchards, Proc. Intern. Seminar, Warsaw Agric. Univ., Poland, 97-98.
16. Wertheim S.J. (1981) High density planting: development and current achievements in the Netherlands, Belgium and West Germany. Acta Hort., 114, 143.
17. Ystaas J. and Frøynes O. (1993) Effects of the Polish rootstocks P 2 and P 22 on vigour, yield and fruit characteristics of apple cultivar ′Gravenstein′. Acta Agric. Scand., Sect. B, Soil and Plant Sci., 43, 244-246.

IMPROVEMENT OF AFTER-RIPENING AND GERMINATION OF APPLE AND PEAR SEEDS
PĒCBRIEDES UN DĪGTSPĒJAS UZLABOŠANA ĀBEĻU UN BUMBIERU SĒKLĀM

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Kopsavilkums

Pētījuma mērķis bija novērtēt sējeņu audzēšanas jauno metodi, kura izveidota Varšavas Lauksaimniecības Universitātē. Šķirņu 'Golden Delicious', 'Ligol' un 'Melrose' krustojumu āboli tika ievākti oktobrī un glabāti 2-3°C līdz februārim. Tad sēklas izdalītas no āboliem un iesētas kastēs ar mitru sfagnu sūnu substrātu, kurš bagātināts ar barības vielām. Šīs kastes novietotas 2-3°C temperatūrā uz 59 dienām un tad pārvietotas uz neapkurināmu plēves seguma siltumnīcu. Dīgšanas spars izvērtēts kā vidējais dienu skaits, kurš nepieciešamas līdz dīgļlapu izdīgšanai. Līdzīgi pētījumi tika veikti arī ar bumbieriem, kuru sēklas tika iegūtas no četriem *Pyrus communis* L. un *Pyrus pyrifolia* Nakai šķirņu krustojumiem. Ābelēm 86.7-97.1% sēklu sadīga vidēji 2.5 - 4.2 dienās. Metode atzīta par piemērotu.

Abstract

The aim of this study was to assess the suitability of a new method of after-ripening of apple seeds, developed at the Warsaw Agricultural University, for raising seedlings in a breeding process. Apples of 'Golden Delicious', 'Ligol' and 'Melrose', obtained from twelve different cross combinations, were harvested in October and stored at 2-3°C till February. Then seeds were removed from fruits and sown individually in trays filled with moist sphagnum peat, enriched with nutrients. Trays were placed in cold storage at 2-3°C for 59 days and then transferred to an unheated plastic tunnel. Germination was recorded daily and germination rate expressed as an average number of days required for emergence of cotyledons. A similar treatment was applied to pear seeds obtained from four interspecific cross combinations, involving cultivars belonging to *Pyrus communis* L. and to *Pyrus pyrifolia* Nakai. In total, 2880 apple and 960 pear seeds were investigated. Percentage of germinating apple and pear seeds was high (86.7-97.1%). Seeds germinated very fast, within 2.5-4.2 days. The presented method is easy to apply, does not require drying of seeds and provides a high output of seedlings in a short time after stratification.

Keywords: apple cultivars, breeding, pear hybrids, after-ripening, stratification, seed germination

Introduction

Seeds of woody plants are often heterogeneous in respect to the length of dormancy period (Nielsen, 1988). Suszka (1989) found that for germination of undried seeds of crab apple (*Malus sylvestris* Mill.) a 14-week stratification at 3°C was needed while for dried seeds – 15 weeks. When stratification at 3°C was continued, more than 90% germinated within 6 weeks. Czynczyk *et al*. (1974) showed that length of dormancy of 'Antonovka' seeds differed between years; from 70 to 86 days were needed for the stratification of dry seeds for starting germination. Considerable differences in the length of the seed dormancy period present a problem in production of seedlings. Conventionally stratified seeds sown outdoors do not overcome dormancy completely. High temperature and dry soil can induce the secondary dormancy of such seeds (Kamiński and Zagaja, 1974). To prevent this undesirable phenomenon, in some apple breeding programmes seeds are inspected during stratification. The germinating ones are sown on trays in a greenhouse (Blažek, 2000). Modifications of stratification treatment of seeds were also applied (Tylkowski, 1978; Lateur *et al*., 2000).

A new method of after-ripening of apple seeds, adapted to the production of seedlings in an unheated plastic tunnel, has been developed at the Department of Pomology and Basic Natural Sciences of the WAU (Pitera, 2003; Pitera *et al*., 2004). The main advantage of this method, in comparison to the conventional stratification, is that practically all the seeds overcome dormancy. It is very easy to apply, does not require the drying of the seeds and allows to obtain a high percentage of seedlings in a short time after stratification. The aim of the experiment, conducted in the years 2004 and 2005 was to assess the suitability of this method for raising apple and pear seedlings in a breeding programme. Pear seeds obtained from interspecific crosses of cultivars (*P. communis* and *P. pyrifolia*) have never been investigated in Poland.

Materials and Methods

Apples of 'Golden Delicious', 'Ligol' and 'Melrose', obtained from 12 different cross combinations, were harvested on October 7, 2004 and stored at 2°C till February 14, 2005 (Table 1). Then the seeds were removed from the fruits and individually sown in trays filled with moist sphagnum peat enriched with nutrients. Trays were placed in cold storage at 2-3°C, for 59 days (till April 14, 2005). A similar stratification treatment was applied to pear seeds. It differed only in the harvest date and length of fruit storage. Fruits were obtained from 4 interspecific cross combinations between 'Conference' (*Pyrus communis*) and 'Chojuro', 'Hosui' and 'Shinseiki' Asian pears (*Pyrus pyrifolia*) – Table 2. Fruits were harvested on September 14 ('Chojuro'), and September 22, 2004 ('Conference'). Seeds were stratified for 59 days in the same way as apple seeds. The length of stratification of seeds in cold storage was established according to previous experiments (Pitera *et al*., 2004).

All trays with apple and pear seeds were transferred on April 15 from cold storage to an unheated plastic tunnel. The stratification treatment consisted of 4 replications, each of 60 seeds. The total 2880 seeds of apple and 960 pear seeds were investigated. The germination of seeds was recorded when cotyledons emerged above the substrate and the germination rate were expressed as an average number of days required for germination of a seed. The germinating seeds were recorded daily. The results were elaborated by analysis of variance. The significance of differences between treatment means was evaluated using the Newman-Keuls test, at α=0.05.

Results and Discussion

The results, presented in Table 1 and 2, show a high or very high percentage of germinated apple and pear seeds, ranging from 86.7% ('Melrose' × 'Gala') to 97.1% ('Ligol' × U 6407). Out of nine pollinators used for 'Melrose', only 'Gala' resulted in a significantly lower (by 9.3%) germination of 'Melrose' seeds, in comparison to the 'Melrose' seeds obtained from pollination with 'Sawa'.

The cumulative germination percentage of pear seeds obtained from four interspecific cross combinations was high ranging from 90.7 to 93.1% (Table 1).

Table 1. Percentage of apple seeds germinated in an unheated plastic tunnel – after extraction from fruits stored at 2 -3°C and stratification in trays for 59 days at 2 -3°C

Cross combinations	Seed number	Germinated seeds, %	Germination rate, No. of days	**Harvest date**
Golden Delicious × U 6407	240	96.3 b[1]	4.2 c	Oct. 7, 2004
Ligol × U 6407	240	97.1 b	3.8 bc	Oct. 7, 2004
Ligol × U 641	240	96.7 b	4.0 c	Oct. 7, 2004
Melrose × Gala	240	86.7 a	4.0 c	Oct. 7, 2004
Melrose × Gala Must	240	87.9 ab	4.0 c	Oct. 7, 2004
Melrose × Idared	240	94.6 ab	2.7 a	Oct. 7, 2004
Melrose × McIntosh	240	90.0 ab	2.6 a	Oct. 7, 2004
Melrose × Rajka	240	87.9 ab	3.3 b	Oct. 7, 2004
Melrose × Rubin	240	93.8 ab	3.2 b	Oct. 7, 2004
Melrose × Sawa	240	96.0 b	3.3 b	Oct. 7, 2004
Melrose × U 641	240	93.8 ab	2.6 a	Oct. 7, 2004
Melrose × U 7156	240	90.7 ab	4.0 c	Oct. 7, 2004

[1] Mean separation by Newman-Keuls test, at α=0.05.

The percentage of germination of 'Conference' (*P. communis*) seeds was not influenced by Asian pear (*P. pyrifolia*): cultivars 'Chojuro', 'Hosui' and 'Shinseiki', used as pollinators. Germination percentage of seeds of Asian pear 'Chojuro' pollinated by 'Conference' was very similar to that of seeds of 'Conference' pollinated by Asian pear cultivars.

Table 2. Percentage of germinated pear seeds in an unheated plastic tunnel – after extraction from fruits stored at 2 -3°C and stratification in trays for 59 days at 2-3°C

Cross combinations	Seeds number	Germinated seeds (%)	Germination rate (No. of days)	**Harvest date**
Chojuro × Conference	240	91.3 a[1]	2.5 a	Sep. 14, 2004
Conference × Chojuro	240	91.8 a	2.9 ab	Sep. 22, 2004
Conference × Shineseiki	174	90.7 a	2.7 a	Sep. 22, 2004
Conference × Hosui	240	93.1 a	3.2 b	Sep. 22, 2004

[1] For explanations see table 1

Apple and pear seeds germinated fast after transfer from cold storage to the unheated plastic tunnel (Fig. 1 and 2). Average day & night temperatures during first six days after sowing ranged from 14 to 18°C. Germination rate was low (2.5-4.2 days) and influenced by some pollinators (Table 1 and 2).

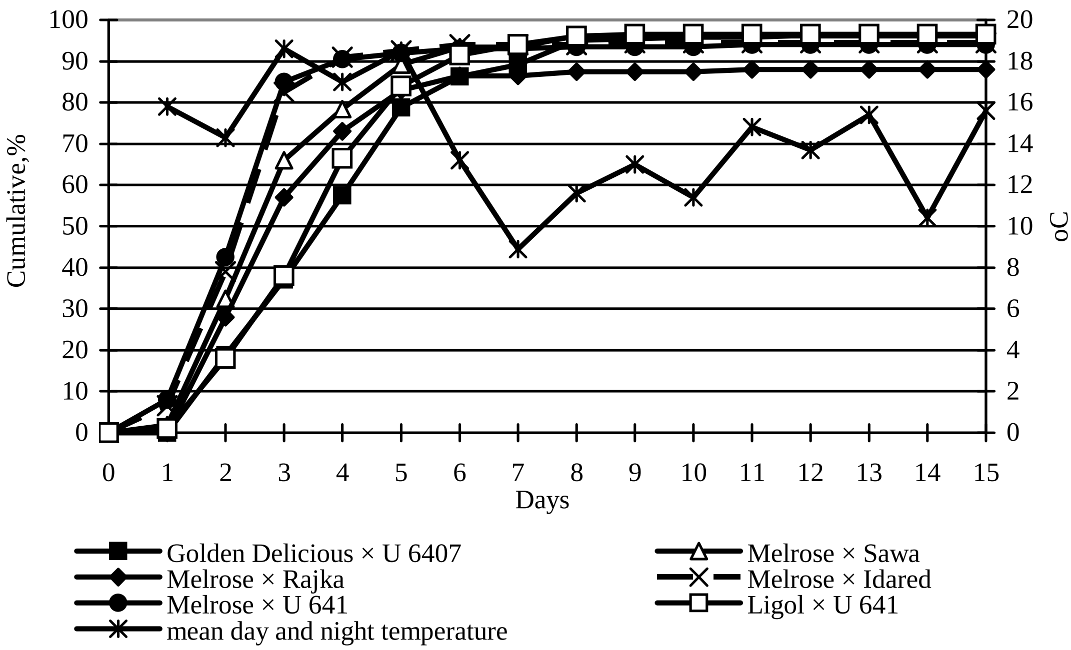

Figure 1. Cumulative seed germination of selected apple progenies

The percentage of germination of seeds of 12 apple and 4 pear progenies (from interspecific crosses) was high and very high. The new method of after-ripening has proved to be useful in conventional apple and pear breeding. It can be also used in the production of rootstocks (Odziemkowski *et al*., 2004). The main advantage of this method, in comparison to the conventional one, is that practically all seeds overcome dormancy. This was possible because seeds were stratified after individual sowing in trays filled with moist sphagnum peat. The proper length of stratification must ensure the breaking of the dormancy of all seeds. In the course of stratification at 2-3°C, seeds with short dormancy germinated in the tray below the surface of the medium (Tylkowski, 1978; Pitera *et al*., 2004). In our experiment 59 days of stratification was enough for breaking the dormancy of most seeds, because after transferring them to the plastic tunnel they germinated in a short time. The temperature in the plastic tunnel was relatively high (Figure 1 and 2).

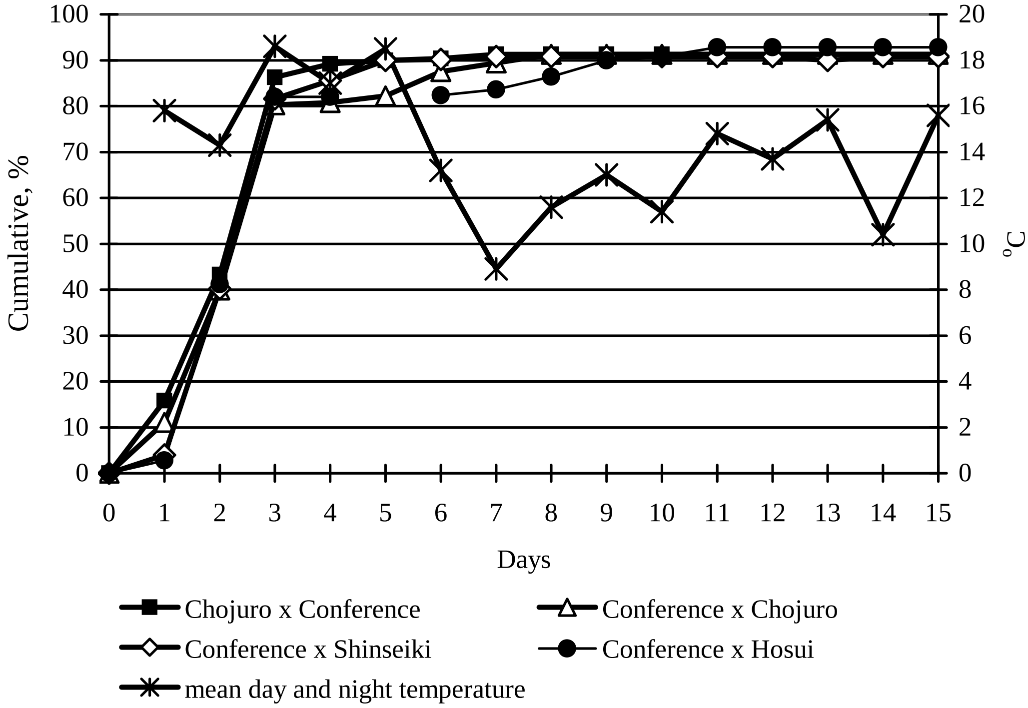

Figure 2. Cumulative seed germination of pear progenies from interspecific crosses

The shorter stratification than used by other breeders may be explained by the treatment of seeds in fruits during storage at 2-3°C. Seeds from fruits stored at that temperature need a shorter period of stratification than dry seeds (Bartlett, 1961; Grzyb *et al*., 1969; Pitera and Odziemkowski, 2003). Tylkowski (1978) used a similar method of stratification for determining true germinability of dry seeds. He showed that the highest percentage of germination of 'Antonovka' seeds was obtained when they were transferred to a temperature of 15°C after 80 days at 3°C. Lateur *et al*. (2000) stratified individual apple seeds in humid peat pots for 90 days at 3-4°C; however, he used dry seeds.

Conclusions

A method of after-ripening of seeds presented in this experiment is useful in the production of apple and pear seedlings. It is easy to apply, doesn't require the drying of seeds and ensures a high output of seedlings in a short time after stratification.

References

1. Bartlett C.E.C. (1961) The after-ripening of apple seeds in the fruit during cold storage. Ann. Rep. Agr. and Hort. Long Ashton. Res. Sta. Bristol, 66–67.
2. Blažek J. (2000) Mildew (*Podosphaera leucotricha* Ell. et Ev./Salm.) susceptibility in apple progenies with segregation for scab resistance. Acta Hort., 538, 257-262.
3. Czynczyk A., Zagaja S.W. and Wojniakiewicz A. (1974) Wpływ zapylaczy na rozwój i kiełkowanie nasion oraz wzrost i wytrzymałość na mróz siewek Antonówki Zwykłej. Prace Inst. Sad. ser. A, 18, 25-31.
4. Grzyb Z.S., Zagaja S.W. and Kamiński W. (1969) Przebieg posprzętnego dojrzewania nasion w przechowywanych owocach jabłoni. Prace Inst. Sad., 13, 39-50.
5. Kamiński W., and Zagaja S.W. (1974) Spoczynek wtórny nasion jabłoni. Część I. Wpływ podwyższonych temperatur. Prace. Inst. Sad. ser. A,-18, 3-8.

6. Nielsen K.K. (1988) Dormancy in seeds from different positions on individual plants. Acta Hort., 226, 255-261.
7. Lateur M., Lefrancq B. and Wagemans C. (2000) Influence of scab inoculum concentration in an apple breeding program focused on quantitative resistance. Acta Hort., 538, 249-255.
8. Odziemkowski S., Pitera E. and Ścibisz K. (2004) Wstępna ocena przydatności nowej technologii produkcji podkładek generatywnych gruszy kaukaskiej Zesz. Nauk. ISiK, 12, 251-256.
9. Pitera E. (2003) Przydatność klonu U 211 w hodowli odpornościowej jabłoni. Rozprawy Naukowe i Monografie. Wydawnictwo SGGW, Warszawa.-106.
10. Pitera, E. and Odziemkowski, S. (2003) Germination of apple seed from fruit removed from cold storage. Acta Hort., 622, 595-598.
11. Pitera E., Odziemkowski S. and Dąbrowska B. (2004) Improvement of seed germination in apple breeding. Acta Hort., 663, 783-787.
12. Suszka B. (1989) After-ripening and germination of crab apple (*Malus sylvestris* Mill.) and common pear (*Pyrus communis* L.) seeds. Arbor. Kórnickie, 34, 101-112.
13. Tylkowski T. (1978) A new method of evaluating the germinability of apple variety Antonówka Zwykła seeds in a cold-warm thermal regime. Arbor. Kórnickie, 23, 153-159.

REDUCTION OF THE TREE PRODUCTION CYCLE OF *IN VITRO* PROPAGATED STANLEY PLUM CULTIVAR AND THE TREE BEHAVIOUR IN AN ORCHARD. 1.GROWTH BEHAVIOUR

\`STANLEY\` PLŪMJU PAVAIROŠANAS CIKLA SAĪSINĀŠANA, IZMANTOJOT PAVAIROŠANU *IN VITRO*, UN KOKU IZVĒRTĒJUMS DĀRZĀ: 1. AUGUMA PARAMETRI

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Kopsavilkums

Plūmju šķirnes \`Stanley\` patsakņu stādi, kuri pavairoti *in vitro* tika audzēti kokaudzētavā vienu un divus gadus. Pētījuma mērķis - noteikt piemērotāko metodi ātrākai stādu ieguvei salīdzinot ar tradicionāli audzētiem (acotiem) stādiem. Tika uzskaitīti un vērtēti sekojoši parametri: stumbra šķērsgriezuma laukums, vainaga tilpums, vainaga projekcijas laukums un koka augstums. Zarojuma struktūra tika novērtēta kā ikgadējais procentuālais pieaugums. Stumbra šķērsgriezuma laukums būtiski neatšķīrās starp variantiem. Tradicionāli pavairotajiem kokiem bija mazāki vainagi. Augļzariņu skaits bija lielāks mikroklonāli pavairotajiem stādiem ar saīsināto audzēšanas ciklu (viengadīgajiem).

Abstract

Own-rooted planting material growth and development in an orchard were studied. An object of the experiment was the plum cv. Stanley produced *in vitro* and further grown in a nursery for one and two years, respectively. The aim of the study was to evaluate the possibility of establishing a plantation with micropropagated plants produced by reducing the period of further growing in the nursery. Their growth habits were compared to trees produced traditionally by grafting and to own-rooted trees produced *in vitro* and further grown in a nursery for two years. The following indices were reported: the increase of the trunk cross-section area, the crown volume, its projection area and the tree height. The structure of the shoots was calculated as a percentage of the total annual growth. Tree trunk thickening did not differ significantly in the years of study for all the three variants. The trees of the control variant had smaller crowns compared to the two own-rooted variants. In the structure of the fruiting wood, the number of the fruit spurs was bigger in the micropropagated trees produced by reducing the cycle.

Key words*:* micropropagation, own-root, fruit tree, growth, plum, behavior.

Introduction

The production technology of plum cultivar planting material by grafting is carried out by a two-year production cycle preceded by the production of seedling rootstocks in a seedling nursery. The application of the *in vitro* method in agriculture offers some advantages in fruit species propagation compared to the conventional technology. The most significant thing in an economic aspect is the possibility of reducing the production cycle (Zimmerman, 1988). Propagation of own-rooted fruit cultivars by the *in vitro* method combined with shortening of the technological cycle for further growing of the adapted microplants offers real opportunities for reducing the production expenses and lowering the price of the planting material. The results of the experiments for reducing the production cycle in obtaining planting material of cultivar Stanley produced by micropropagation and further grown in a nursery only for a year, were positive. The technology provided the opportunity of reducing the production expenses of the own-rooted trees (in press). It was necessary to evaluate the behavior of the planting material, produced by reducing the cycle, in an orchard.

Materials and Methods

The study was carried out in the fields of the Fruit Growing Institute – Plovdiv in the period 1993-2004. The object of the experiment was the plum cultivar Stanley. Own-rooted micropropagated trees (produced without grafting), further grown in a nursery for only one vegetation period, were studied. Trees further grown in a nursery for two years and trees grafted on the seedling rootstock Janka 4 (*Prunus cerasifera* Ehrh.) obtained by the traditional technology for grafted fruit tree planting

material, were produced and planted on the experimental plot for control. The explants and the cuttings for grafting were collected from the same trees planted and grown for that purpose. The trees were planted at 6 m distance between the rows and 4 m distance within the rows. The experimental plot was grown under irrigation conditions; the space between the rows was periodically tilled. Pruning was very slight – only in the first years – for training of free growing crown. Stem thickening, the crown size and height were measured during vegetation. The trunk cross-section area, the crown volume and the projection area were calculated. The growth size and its structure during the first two years in the plantation were evaluated for the whole trees, in the following years the information was collected only from one skeleton branch. The morphological characteristics were visually observed for detecting any eventual changes caused by the method of propagation.
Data were statistically analysed by using Anova – single factor and Duncan test.

Results and Discussion

Tree stem thickening did not differ significantly during the years of the study for all the three variants (Fig. 1). Stem thickening reflecting the growth characteristics of the variants during the different vegetation periods were insignificant, but still, in favor of the control trees. The stem thickening of the micropropagated trees, planted with their one-year old root system, was like those further grown in the nursery for two years. At the end of the investigation period the stem size proportion between separate variants was the same like at the end of the first vegetation. The differences in the tree stem size of all three variants were statistically insignificant.

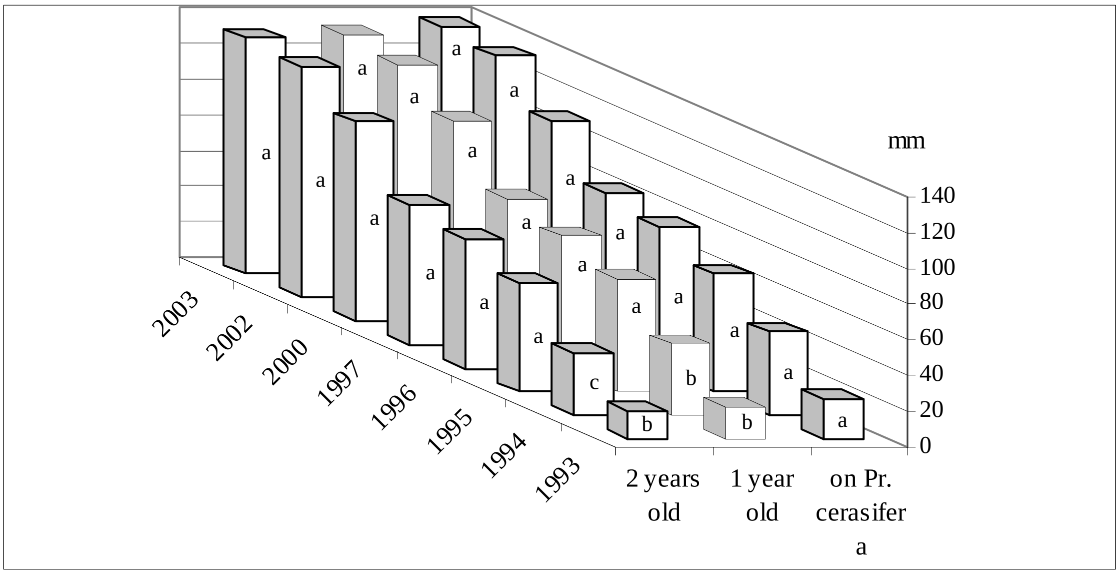

Figure 1. Stem diameter of micropropagated own-rooted trees produced by reducing the cycle and of grafted trees of cv. 'Stanley'

The trees grown by reducing the production cycle had a bigger crown volume until the beginning of fruiting and in the first two years of initial fruiting, in comparison to those variants where trees were further grown in the nursery for two years (Fig. 2). In the period of study the crowns of micropropagated trees were also bigger in comparison to the trees of the control variant, grafted on Janka 4. Five years later the own-rooted trees further grown in a nursery for two years were of a bigger size compared to the trees of the other two variants, the tendency was maintained till the end of the investigation. Thus the trees of the control variant had smaller crowns than those of the two own-rooted tree variants, what coincide to the opinion of Faber *et al.* (2002). Concerning this parameter, our results did not confirmed findings of Sansavini *et al.* (1990) about own-rooted trees of Obilnaya cultivar. According to their studies the own-rooted trees in the seventh year after planting in the orchard had 40 % weaker growth in comparison to those grafted on Myrobalan.

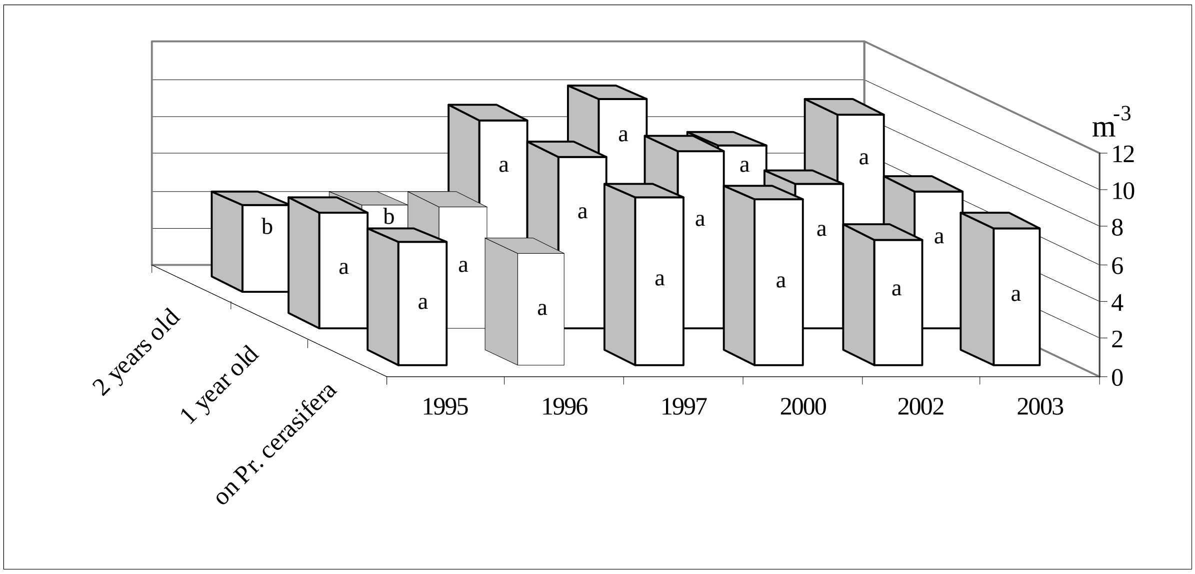

Figure 2. Grown volume of micropropagated own-rooted trees produced by reducing the cycle and of grafted trees of cv. 'Stanley'

The biggest crown projection area was observed for the younger own-rooted trees (Fig. 3) in all years of investigation, except the last year. It was resulted from the bigger values of the mean shoot length and their number. The early beginning of fruiting also had an effect on the crown projection area, because the branches of those trees declined under the weight of the fruits. The angle of bending of the skeleton branches had also important influence. They were more obtuse in comparison to the angle measured in the other own-rooted variant, as well as to the angle measured in the control. That contributed additionally to reaching higher values of the crown projection area in the trees further grown following the reduced production cycle. The tendency was maintained until the last two years of the tree recultivation.

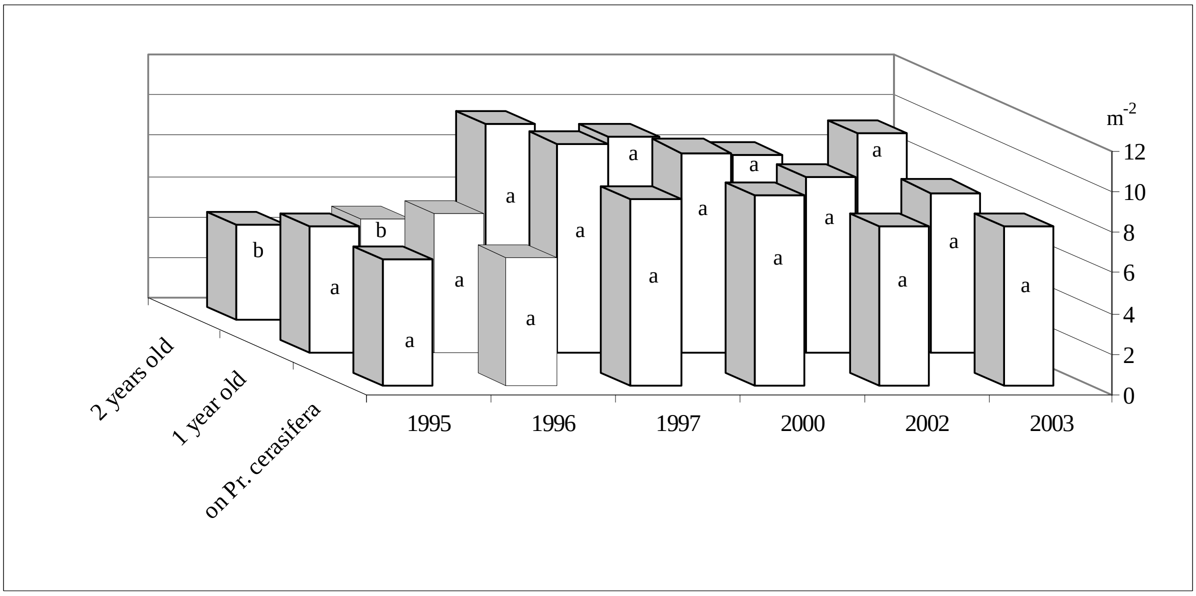

Figure 3. Crown projection area of micropropagated own-rooted trees produced by reducing the cycle and of grafted trees of cv. 'Stanley'

During the first years the trees of the control variant grew more vigorous in comparison with the own-rooted trees of the two other variants. Concerning the characteristics, the year younger own-rooted trees occupied an intermediate position. The own-rooted plants grown further in a nursery for two years were of the less vigorous habit in the first three years of cultivation later at the second half of the period of investigation they grew significantly faster. As a result of the most vigorous habit, the tree crown volume in this variant was also bigger but it did not affect the crown projection area. It shows that the crown volume is more dependent on the tree height rather than on the tree spacing in and between the rows. Similar to the results of another experiment (Popov *et al.*, 2000) the own-rooted micropropagated trees had more obtuse angles of bending of the skeleton branches at the lowest crown layer. It was very obviously expressed in the trees grown in the nursery for a shorter period. Probably this tendency was additionally intensified by the fruit weight in second vegetation after establishing the experimental fields.

Both, the traditionally produced trees and the own-rooted ones grown for the one year in the nursery, had twice vigorous growth of the shoots in comparison to the trees grown in the nursery for two years after micropropagation. During the second vegetation season the total length of the shoots in the variant produced for a year surpassed significantly all the rest and the growth shoot length of the trees of the other own-rooted variant was the same as of the grafted trees. The bigger total length of the shoots of the own-rooted trees was caused by the development of significantly higher number of shoots during the second vegetation. In the third year of field cultivation, the growth increase in the control trees was significantly higher in comparison to the trees of the reduced production cycle and almost twice higher than in the other own-rooted variant.

The intensive tree growth continuing in the second year of the fruiting was at the expense of their shoots. In all the three variants the share of that type of shoots was the same and it formed two thirds of the sum total of the annual growth (Fig. 4). In the control trees the initiation of the feathers was expressed stronger in comparison with the own-rooted trees.

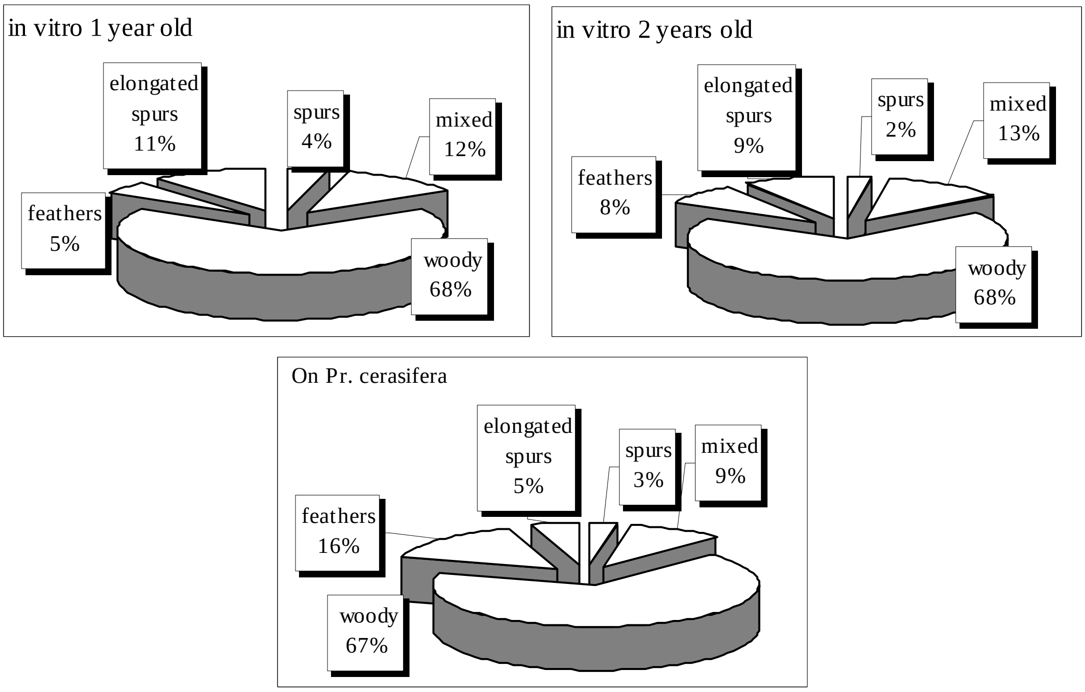

Figure 4. Structure of the annual growth of micropropagated own-rooted trees produced by reducing the cycle and of grafted trees of cv. ‘Stanley’ in the first years of cultivation in an orchard

Conclusions

Tree stem thickening in all the three variants did not differ significantly during the years of study.

The own-rooted trees grown in a nursery for two years formed more volume crowns than those grafted on Janka 4 (*Pr. cerasifera*) and trees produced by reducing the cycle. This tendency was maintained until the end of the investigation period. The trees of the control variant produced by grafting on a seedling rootstock had smaller crowns compared to both own-rooted variants.

The skeleton branches of the own-rooted micropropagated trees spread into more obtuse angles. That was more expressed in the trees grown for a shorter period in the nursery.

References

1. Faber.T., Lech W., Malodobry M. and Dziedzic E. (2002) Assessment of growth and cropping of the plum trees growing on Wagenheim prune rootstock and originated in vitro. Acta Horticulturae, 577, 51-56.
2. Popov S. and Zhivondov A. (2000) Growth habits of micropropagated true rooted trees of Stanley plum cultivar. Journal of Mountain Agriculture on the Balkans, vol. 3, 2, 380-390.
3. Sansavini S., Buscaroli, C., Martelli, S. and Palara U. (1990) Osservazioni sul comportamento di susini micropropagati e innestat. Rivista di Fritticoltura e di Ortofloricoltura, 52, 6, 35-38.
4. Zimmerman R. H. (1988) Micropropagation of woody plants: post tissue culture aspects. Acta Horticulturae, 227, 489-499.

REDUCTION OF THE TREE PRODUCTION CYCLE OF *IN VITRO* PROPAGATED STANLEY PLUM CULTIVAR AND THE TREE BEHAVIOUR IN AN ORCHARD. 2. REPRODUCTIVE BEHAVIOR
STANLEY PLŪMJU PAVAIROŠANAS CIKLA SAĪSINĀŠANA, IZMANTOJOT PAVAIROŠANU *IN VITRO* UN KOKU IZVĒRTĒJUMS DĀRZĀ: 2.REPRODUKTĪVIE PARAMETRI

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Kopsavilkums

Viengadīgi un divgadīgi mikroklonāli pavairoti plūmju šķirnes `Stanley` stādi tika salīdzināti ar tradicionāli pavairotiem stādiem, kuri acoti uz potcelma Janka 4 (*Prunus cerasifera* Ehrh.). Mērķis - novērtēt ražu un ekonomisko efektivitāti dārzā. Tika izvērtēti sekojoši parametri: ražošanas sākums, raža un ražas efektivitāte izteikta kā ražas un stumbra šķērsgriezuma laukuma attiecība, kā arī ražas un vainaga projekcijas laukuma attiecība. Saīsinātā stādu audzēšanas ciklā iegūtie mikropavairotie stādi sāka ražot otrajā gadā, tāpat kā acotie, bet tiem bija mazāk augļu un pirmajā ražas gadā ziedpumpuri bija izvietoti zaru galos. Patsakņu kokiem bija zemāka raža, salīdzinot ar acotajiem. Ražas efektivitāte augstāka bija mikropavairotajiem stādiem.

Abstract

The study was carried out on the reproductive behaviour of own-rooted micropropagated trees of ‘Stanley’ plum cultivar grown for only a year in a nursery. Traditionally produced trees grafted on the seedling rootstock Janka 4 (*Prunus cerasifera* Ehrh.) as well as *in vitro* propagated trees of the same cultivar, but grown in the nursery for two vegetation periods, were planted for comparison. The aim of the study was to establish the reproductive and economic qualities of the micropropagated own-rooted planting material produced by reducing the cycle and to evaluate the possibility of establishing fruit orchards from these plants. The following characteristics were observed: beginning of fruiting, yield, biometric indices and fruit production efficiency expressed as yield to trunk cross-section area and to crown projection area ratios. The trees obtained by reducing the production cycle began to bear fruits during the second vegetation like grafted trees. They had less fruit buds per tree compared to the grafted ones and the buds were located in the apical parts of the shoots. Such juvenile behaviour was observed only for the first year after the beginning of fruiting. The own-rooted trees were less fertile in comparison to the grafted ones. However, there were no differences in fruit quality and in the biometric indices. The efficient productivity calculated on the basis of the trunk cross-section area and the crown projection area was higher than that of the traditionally produced trees.

Keywords: micropropagation, own-root, fruit tree, yield, plum, behavior.

Introduction

The efficiency of a plantation is determined by the production value and the price of the planting material, as well as by the economic results depending on the reproductive behaviour of the trees used. The *in vitro* method is a modern approach in the propagation of rootstocks and own-rooted cultivars of species for which the traditional methods proved to be difficult to apply or inapplicable at all. Reducing the nursery production cycle of micropropagated own-rooted trees of Stanley cultivar is a fact and the application of this technology in practice enabled the establishment of orchards using such planting material. Its behavior in orchard was unknown. Therefore necessity of the studies in this question was defined.

In the results of some investigations delayed beginning of fruiting was reported (Cobianchi *et al.*, 1988). The lower yields resulting from the poorer growth were underlined as the problem of using micropropagated own-rooted trees. Because of the poorer growth of that type of trees their productivity was higher in comparison with the grafted ones (Cobianchi *et al.*, 1993; Sansavini *et al.*, 1990). Faber *et al.* (2002) reported that the productivity of the traditionally produced trees of Stanley cultivar was higher. The differences in the reported results as well as the use of planting material produced by the reduced cycle gave us the theoretical base for carrying out the presented study. Its aim was to show the effect of reducing the production cycle by a year on the reproductive behavior of own-rooted micropropagated trees in comparison with the trees grown in the nursery for two years and the traditionally obtained trees by grafting on the seedling rootstocks.

Materials and Methods

The study was carried out in the fields of the Fruit Growing Institute – Plovdiv in the period 1993-2004. The object of the experiment was the plum cv. Stanley. Own-rooted micropropagated trees (produced without grafting), grown in a nursery for only one vegetation period, were studied. Trees grown in a nursery for two years and trees grafted on the seedling rootstock Janka 4 (*Prunus cerasifera* Ehrh.) obtained by the traditional technology for grafted fruit tree planting material, were produced and planted on the experimental plot for control. The explants and the cuttings for grafting were collected from the same trees planted and grown for that purpose. The trees were planted at 6 m distance between the rows and 4 m distance within the rows. The experimental plot was grown under irrigation conditions, the space between the rows was periodically tilled in accordance with the technological requirements for fruit production. Pruning was very slight – only in the first years – for training of free growing crown. Stem thickening, the crown size and height were measured during vegetation. The following indices were reported: beginning of fruiting, yield per tree and total yield for the period, productivity on the basis of the trunk cross-section area and the crown projection area, as well as fruit quality expressed by fruit and stone biometry. The morphological characteristics were visually observed for detecting any eventual changes resulting from the method of propagation.
Data were statistically processed by applying Anova – single factor and the Duncan test.

Results and Discussion

First flowering was reported during the second vegetation after planting in the spring of 1993. All the three variants had flower buds. In the micropropagated variants the flowering trees were 66.7 – 68.8 % for those produced for one and those produced for two years, respectively, while 93.3 % of all the grafted trees had flowers. The own-rooted trees formed 4 to 5 times less flower buds than those grafted on the seedling rootstock Janka 4 (*Pr. cerasifera* Ehrh). At the end of the vegetation single fruits were also reported in 60 % of the grafted trees and in 13.3 and 25 % of the own-rooted *in vitro* propagated trees, grown in a nursery for one and for two years, respectively.

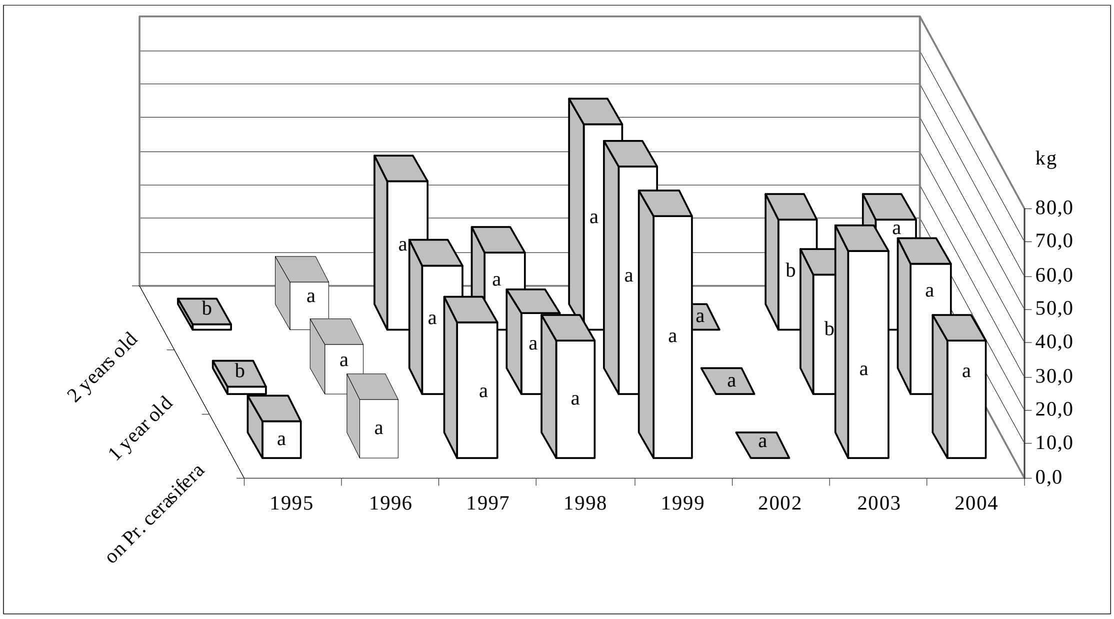

Figure1. Fruit yield of micropropagated own-rooted trees of cv. 'Stanley'produced by reducing the nursery cycle

The own-rooted trees had flowers located in the apical part of the shoots, a fact typical of the juvenile seedling plants. That was observed only in the first year of flowering. By the fertility index the own-rooted micropropagated trees of both variants fell behind the traditionally produced ones. The bigger number of flowers in the first years after the beginning of fruiting brought the higher yields per tree in the variant with grafted trees. The tendency was maintained until the end of the study period. The trees produced by reducing the nursery cycle were slightly more fertile than the own-rooted ones grown for two years in the nursery with the exception of the year 1997. Maximal yields per tree were obtained - 72.2 kg, 67.8 kg and 61.4 kg, respectively, from the grafted trees, the own-rooted trees grown for one and for two years in a nursery (Fig. 1).

The total yield per tree for the period of investigation was the highest for the traditionally produced - 272.8 kg versus 221.8 kg and 210.3 kg for the trees produced by reducing the nursery cycle and for those grown for two years in the nursery, respectively. The yields calculated as a ratio to the trunk cross-section area (Fig. 2) and to the crown projection area (Fig. 3) showed that the traditionally produced trees had higher values of production efficiency at the end of the period. The differences were statistically insignificant.

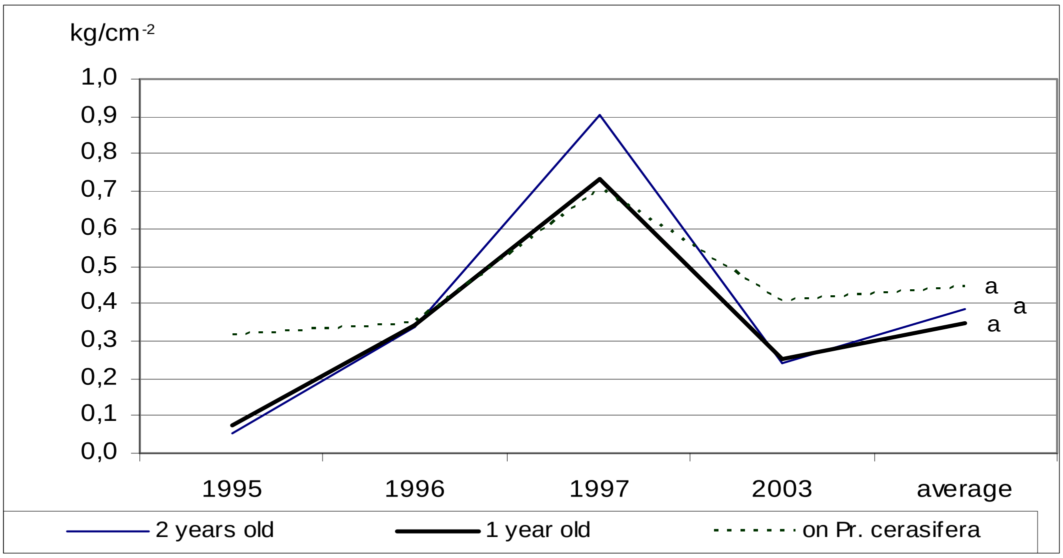

Figure 2. Productivity according to trunk cross-section area, kg cm^{-2}

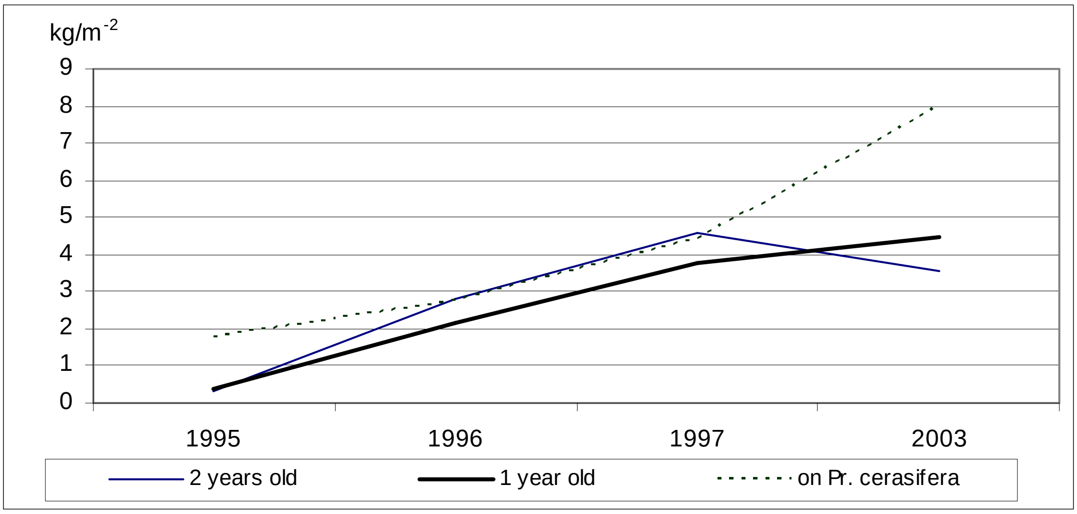

Figure 3. Productivity according to crown projection area, kg m^{-2}

The average fruit mass for three years varied insignificantly between 2.99 to 32.6 g (Fig. 4). The fruits of the micropropagated trees were slightly bigger in comparison to the traditionally produced, probably due to the smaller number of fruits per tree and, respectively, to the lower yield. The fruit size expressed in grams correlated to the stone weight. No big differences among the three variants were detected in the sizes of the fruits and stones. They were statistically insignificant. It confirmes the lack of any pomological changes resulting from the propagation method and the application of the original technology developed at the Fruit Growing Institute – Plovdiv. Variations of the fruit and stone sizes increased with tree aging, the value of the variation coefficient about the length of the fruit peduncle being almost twice higher at the end of the period.

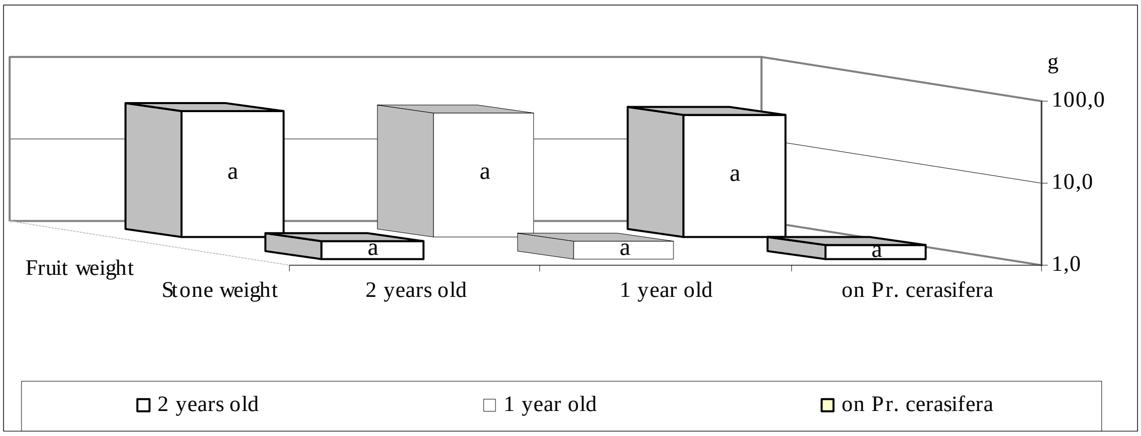

Figure 4. Average weight of fruits and stones of micropropagated own-rooted trees of cv. 'Stanley' plum produced by reducing the nursery cycle.

It should be mentioned that our results definitely confirmed the opinion of Sansavini *et al.* (1990) about the fact that fruit quality was not affected by the method of propagation and production of the planting material. The visual observations on the morphological characteristics of leaves, shoots, flowers, period of flowering, fruit ripening and the separate phenophases during vegetation also did not show any differences between the trees produced by different methods. The technology of reducing the production cycle of the own-rooted micropropagated trees can be applied in practice due to the lower product cost and lower price of the planting material. However, at the establishing of orchards it should be taken into account that the yields and productivity are slightly lower.

Conclusions

The micropropagated own-rooted trees grown for a year in a nursery, began to fruit in the second vegetation after planting in the orchard, similar to the trees grown in the nursery for two years and the trees grafted on seedling rootstocks.

The total yield per tree for the period of study was the highest for the traditionally produced trees of Stanley cultivar. The own-rooted plants produced by reducing the nursery cycle were slightly more fertile than the trees of the other variant with micropropagated trees.

In the period of full fruiting pomological changes as a result of the micropropagation were not observed concerning the fruits and stones, which was also confirmed by the comparatively slight differences in the biometric sizes.

The establishment of fruit orchards with planting material produced *in vitro* and further grown in a nursery for only a year is possible and not risky at all. It should be kept in mind that the lower yield in both variants with own-rooted trees is a fact and it should not be neglected when making the final decision.

References

1. Cobianchi D., de Salbador F. R., Faedi W., Insero O., Liverani A., Rivalta I., Minguzzi A. and Marani M. (1988) Preliminary field observations on *in vitro* propagated trees. Acta Horticulturae, 227, 514-516.

2. Cobianchi D., de Salvador R., Faedi W., Insero O., Liverani A., Maltoni M. L., Minguzzi A. and Rivalta L. (1993) Comportamento in campo di materiale varietale propagato in vitro L'informatore Agrario, Verona, XLIX (23), 57-66.
3. Faber T., Lech W., Malodobry M. and Dziedzic E. (2002) Assessment of growth and cropping of the plum trees growing on Wagenheim prune rootstock and originated in vitro, Acta Horticulturae, 577, 51-56.
4. Sansavini S., Buscaroli C., Martelli S. and Palara U., (1990) Osservazioni sul comportamento di susini micropropagati e innestati. Rivista di Fritticoltura e di Ortofloricoltura, 52, 6, 35-38.

THE EFFECT OF ATMOSPHERIC CARBON DIOXIDE ENRICHMENT ON THE GROWTH OF BLUEBERRY SOFTWOOD CUTTINGS
ATMOSFĒRAS CO_2 BAGĀTINĀŠANAS IETEKME UZ KRŪMMELLEŅU LAPOTO SPRAUDEŅU AUGŠANU

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Kopsavilkums
Šķirņu 'Earlyblue', 'Spartan', 'Blueray', un 'Bluecrop' augstcelmu mellenes (*Vaccinium corymbosum* L.) un savvaļas suga Oobasunoki (*Vaccinium smallii*) 2002. gadā no 16. jūlija līdz 14. novembrim tika spraustas mitrā kūdras substrātā un audzētas augšanas kamerā normālā atmosfēras gāzu sastāvā un paaugstinātā (1000 mg l^{-1}) CO_2 koncentrācijā. Izmēģinājums tika pārtraukts 2003. gada 8. aprīlī, atsākoties dzinumu augšanai. Konstatēts, ka paaugstināta CO_2 koncentrācija pozitīvi ietekmējusi spraudeņu augšanu – spraudeņi labāk sakņojušies, vairāk izdzīvojuši, agrāk veidojās saknes, saknes garākas un spēcīgāk zarojās dzinumi.

Abstract
Softwood cuttings of 'Earlyblue', 'Spartan', 'Blueray', and 'Bluecrop' cultivars of highbush blueberry (*Vaccinium corymbosum* L.) and those of the wild species Oobasunoki (*Vaccinium smallii*) were planted in a moisture peat moss medium and were grown in growth chambers at ambient (current atmospheric concentration) or elevated (1000 mg l-1) levels of carbon dioxide from July 16 to November 14, 2002 (leaf fall). The experiment was finished on April 8, 2003 (new growth of shoots). Comparing the two chambers, we found that carbon dioxide enrichment had a definite positive effect on the growth of blueberry softwood cuttings. The effects were manifested in improved rooting and survival ratios, earlier root induction, longer roots, and increased branch growth. It was concluded that carbon dioxide application is a feasible means for achieving faster and mor efficient propagation of highbush blueberry softwood cuttings.

Key words: CO_2 enrichment, highbush blueberry, propagation, softwood cuttings.

Introduction

Rising atmospheric carbon dioxide concentration has become a global problem (Hsiao and Jackson, 1999). In 1998, the concentration of atmospheric carbon dioxide gas in the air reached the level of 368 mg l-1 (Mearns, 2000). The effects of the increased carbon dioxide concentration on growth of rice plants and other agronomic and forest species are well documented (Lawlor *et al.,* 1991, Kimball *et al.,* 2002). Sionit *et al.* (1980) reported that semi-dwarf spring wheat under well-watered conditions showed a 43% increase in the rate of tiller production and significant increases in grain yield, total dry matter, and number and size of the grains in response to atmospheric carbon dioxide enrichment. Sionit (1983) also reported that the limiting effect of nutrient supply could be partly overcome by an increase in the atmospheric carbon dioxide concentration, as was shown in the case of soybeans. Young bean plants were found to grow faster in air enriched with carbon dioxide than in ambient carbon dioxide (Porter and Grodzinski, 1983). Also, the leaf area and dry weight of the bean plants and the starch content in the leaves and stems were significantly increased by carbon dioxide enrichment. Leaf thickness also responded positively to carbon dioxide enrichment (Radoglou and Jarvis, 1992). Scheidegger and Nösberger (1984) found that elevated carbon dioxide concentration positively influenced the dry weight and the starch and sugar accumulation of white clover plants. Rogers *et al*. (1983) reported that corn, soybeans, loblolly pine, and sweetgum species responded with increased yield and wood volume. Water-stressed sweetgum and loblolly pine plants grown in air with elevated carbon dioxide concentration were found to have greater total dry weight (Tolley and Strain, 1984). Tissue *et al.* (1993) found that photosynthetic rates were higher for loblolly pine plants grown at elevated carbon dioxide only when they received supplemental nitrogen. Carbon dioxide enrichment increased the total dry weight by an average of 38% and increased the number, length, diameter and specific weight of the needles of Monterey pine seedlings in studies by Conroy *et al*. (1986, 1987). Carbon dioxide enrichment was reported to enhance the growth of white oak seedlings by 85%, with the greatest enhancement being in the root system, and to increase the proliferation of fine roots

(Norby *et al.*, 1986). Faria *et al.* (1996) reported that the leaves of cork oak grown in a carbon dioxide-enriched atmosphere were protected from the short-term effects of high temperature and that plants grown in an atmosphere with elevated carbon dioxide concentration had positive net carbon uptake rates during a heat shock treatment. They also reported that their recovery after heat shock treatment was faster than that of plants grown in ambient conditions. Radoglou and Jarvis (1990 a, b) reported that four poplar clones responded positively to elevated carbon dioxide with increases in the number of leaves, total length of the stems, total leaf area, overall growth rate, and total leaf, stem and root dry weights. On the other hand, Norby and O'Neill (1990) found that an increase in dry weight of yellow poplar seedlings, resulting from elevated carbon dioxide, occurred only in root systems. The increase in total dry weight of carbon dioxide-enriched sweet chestnut seedlings was reported to be the result of an increase in root dry weight (Mousseau and Enoch, 1989). Glenn and Welker (1997) found that increased root carbon dioxide resulted in increased root growth without increase in the shoot growth of peach trees in soil and hydroponic systems.

Highbush blueberry (*Vaccinium corymbosum* L.) propagation using softwood cuttings is less successful than that of rabbiteye blueberry (*V. ashei* Reade) because of the rooting difficulty of highbush blueberry (Gough, 1994). On the other hand, including the chilling period, hardwood cuttings of highbush blueberry need a longer growing time than that required for the softwood cuttings (Gough, 1994). Therefore, the aims of this study were to establish methods to improve the rooting efficiency of softwood cuttings by elevated carbon dioxide levels and to shorten the nursery time of blueberry clones.

Materials and Methods

A preliminary experiment was carried out from July to April in 2002, and a similar experiment was carried out from July16 to April 8 in 2003. The two experiments were conducted under similar conditions. Five cultivars were used in both experiments: 'Earlyblue', 'Spartan', 'Collins', 'Blueray', and 'Patriot' were used in the first experiment, and 'Earlyblue', 'Spartan', 'Blueray', and 'Bluecrop' cultivars of highbush and Oobasunoki (*Vaccinium smallii*), a wild species blueberry growing near the Field Science Center of Tohoku University in Naruko, were used in the second experiment. Fifty softwood cuttings of each cultivar and 30 softwood cuttings of Oobasunoki were inserted into moisture peat-moss media in rooting boxes, and the boxes were placed in growth chambers under a carbon dioxide-enriched or an ambient atmosphere. The carbon dioxide concentration in the enriched atmosphere chamber was about three-times higher than that in the ambient one (1000 mg l-1 on average). These conditions were maintained during the summer and autumn periods until the falling of leaves. In the second experiment, the first sampling, 20 of the 50 cuttings (10 of the 30 cuttings for Oobasunoki), was done on November 14, 2002. At the first sampling, both the number of rooted cuttings and the numbers of living cuttings were counted and the lengths of the roots were also measured. The rooting ratio and the survival ratio of each cultivar were calculated, and the ratios of cultivars grown in the carbon dioxide-enriched chamber and the ratios of those grown in the ambient chamber were compared. The second sampling was done after finishing the experiment in April. At this time all of the previous indexes were recorded, and the growth rates of new branches were measured. Only the data obtained in the second experiment are shown in this report because the results of the two experiments were similar.

Results and Discussion

Number of rooted cuttings and rooting ratio

The softwood cuttings of blueberry treated at a higher carbon dioxide concentration showed a greater number of rooted cuttings (data not shown) and also a higher rooting ratio than those of the ambient samples as shown in Fig. 1. The highest rooting ratio was in 'Bluecrop' and the lowest ratio was in the 'Spartan' cultivar grown in the carbon dioxide-enriched atmosphere. The 'Spartan' cultivar also had the lowest rooting ratio in the ambient treatment, while the highest ratio was in 'Blueray'.

Means within the same treatment and within the same cultivars were compared by Tukey's HSD test at the 0.05 level of probability. ab, bb, bab, etc...: the first letter shows significant difference between the treatments, and the second and third letters show the significant differences between cultivars.

The difference between rooting ratios of the carbon dioxide-treated and ambient plants, was also observed among the cultivars. 'Earlyblue' and 'Spartan' cuttings in the carbon dioxide treatment group showed rooting ratios about 10-times higher than those in the ambient group, while 'Blueray' and Oobasunoki cuttings showed only 2- and 3-times higher rooting ratios, respectively, in the carbon dioxide-enriched atmosphere. 'Bluecrop' had a 4-times higher rooting ratio in the carbon dioxide treatment chamber than that in the ambient chamber.

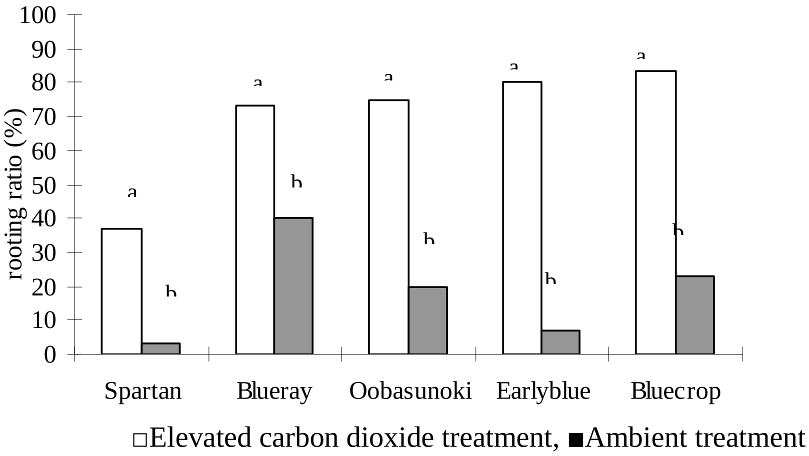

Figure 1. Rooting ratios of blueberry softwood cuttings at the second sampling

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Number of living cuttings and survival ratio

There was little difference among the cultivars in number of living cuttings (data not shown) and survival ratio in the carbon dioxide-enriched atmosphere as shown in Fig. 2. The survival ratios of 'Blueray' and 'Bluecrop' were the highest, while that of 'Spartan' was the lowest. The survival ratio of 'Blueray' cuttings grown in the ambient atmosphere was the highest among the plants tested, while the ratios of 'Spartan' and 'Earlyblue' cuttings were the lowest. The survival ratios in the elevated carbon dioxide atmosphere were about 11-times higher in 'Earlyblue' cuttings, 10-times higher in 'Spartan' cuttings and about 4-times higher in 'Bluecrop' cuttings than those of cuttings in the ambient atmosphere.

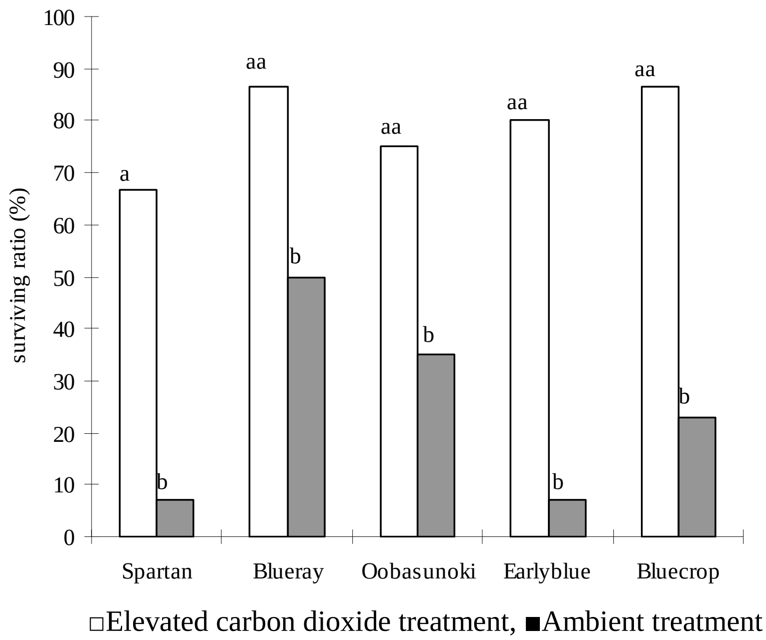
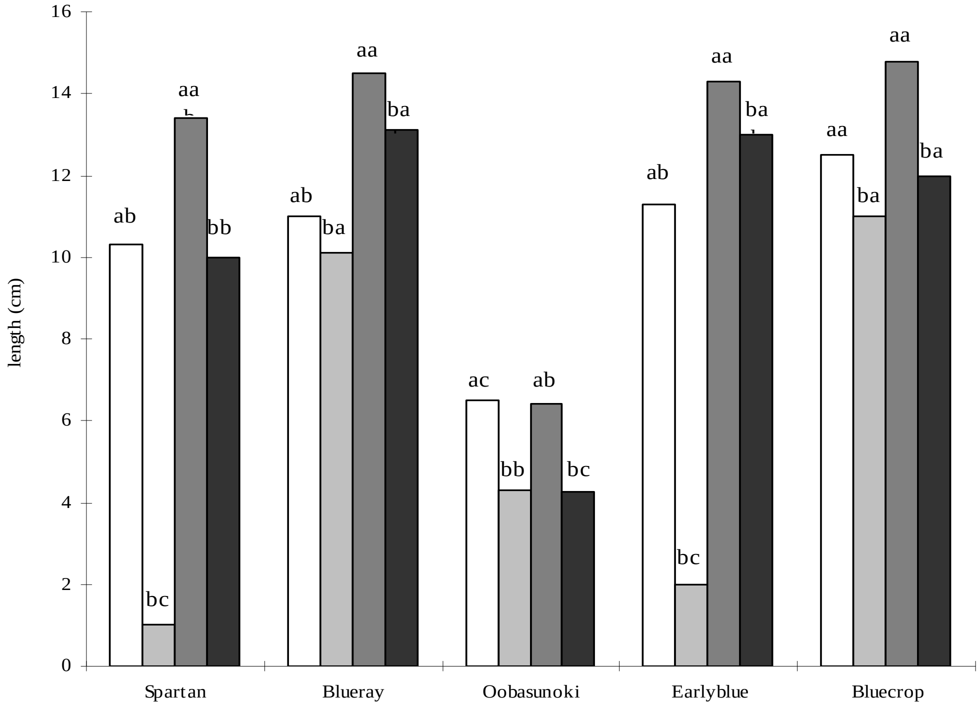


Figure 2. Surviving ratios of blueberry softwood cuttings at the second sampling

Means within the same treatment and within the same cultivars were compared by Tukey's HSD test at the 0.05 level of probability: ab, bb, bab, etc...: the first letter shows significant difference between the treatments, and the second and third letters show the significant differences between cultivars.

Root growth

The lengths of roots were measured and recorded at the first sampling and the second sampling (Fig.3.). A comparison of root lengths at the first and second samplings would clarify the effect of elevated carbon dioxide on the growth rate of softwood cuttings. The cuttings of all the cultivars grown in the elevated carbon dioxide atmosphere had longer roots than those grown in the ambient atmosphere. Carbon dioxide treatment seemed to be the most effective for early root induction of ‘Spartan’ and ‘Earlyblue’ cuttings compared to the other cultivars. They had about 5-times longer roots in the early stage in the elevated carbon dioxide atmosphere than those in the ambient atmosphere. Among the cultivars grown in the elevated carbon dioxide atmosphere, the ‘Bluecrop’ cultivar had the longest roots at both the first and second samplings, while the Oobasunoki wild species had the shortest ones. In the case of ambient treatment, the ‘Bluecrop’ had the longest roots at the first sampling and ‘Blueray’ had the longest roots at the second sampling, whereas ‘Spartan’ had the shortest roots at the first sampling and Oobasunoki had the shortest roots at the second sampling.



□ Elevated carbon dioxide treatment at the 1st sampling, ■ Ambient treatment at the 1st sampling, ■Elevated carbon dioxide treatment at the 2 nd sampling, ■Ambient treatment at the 2 nd sampling

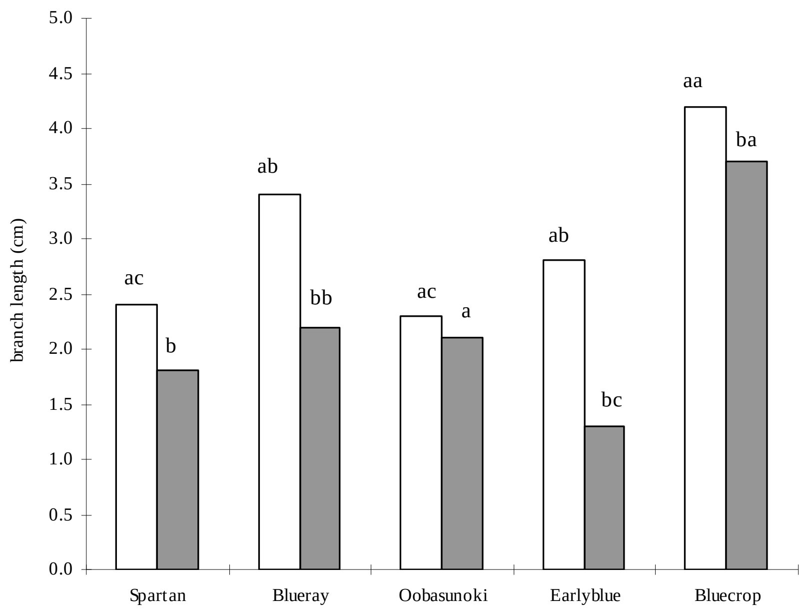
Figure 3. Root lengths of blueberry softwood cuttings at the first and second sampling

Means within the same treatment and within the same cultivars were compared by Tukey's HSD test at the 0.05 level of probability: ab, bb, aab, etc...: see Fig. 1.

Growth of the new branches

The growth of new branches was only measured at the second (spring) sampling, and the data are shown in Fig. 4. Carbon dioxide treatment had a clear effect on growth increment but the growth of new branches was much more influenced by the cultivar effect. Among the carbon dioxide-treated cultivars, the ‘Bluecrop’ cultivar showed the longest new branches and Oobasunoki showed the shortest new branches. In the ambient cuttings, the longest branches were also found in the ‘Bluecrop’ cultivar and the shortest ones were found in the ‘Earlyblue’ cuttings.

The greatest effect of the elevated carbon dioxide level on new branch growth was found in the ‘Earlyblue’ cuttings, the branch growth being two-times greater than that of ambient ones. The least effect of carbon dioxide enrichment on new branch growth was observed in the Oobasunoki cuttings.



□ Elevated carbon dioxide treatment ■Ambient treatment.

Fig. 4. Growth of new branches at the second sampling

Means within the same treatment and within the same cultivars were compared by Tukey's HSD test at the 0.05 level of probability: ab, bb, aab, etc...: see Fig. 1.

Conclusions

The results showed that, carbon dioxide enrichment had a definite positive effect on the growth of softwood cuttings of both blueberry cultivars and the wild species. The effects were manifested in improved rooting ratio and survival ratio, earlier root induction, longer roots, and increased growth. Although the responses of the cultivars to atmospheric carbon dioxide enrichment were different, all of the cultivars responded much more strongly than did the wild species, Oobasunoki. Finally, it can be concluded that carbon dioxide application is a feasible means for achieving faster and efficient propagation of highbush blueberry softwood cuttings.

References

1. Conroy, J., Barlow, E. W. and Bevege, D. I. (1986) Response of *Pinus radiata* seedlings to carbon dioxide enrichment at different levels of water and phosphorus: growth, morphology and anatomy. Annals of Botany, 57, 165-177.
2. Conroy, J., Küppers, M., Küppers, B., Virgona, J. and Barlow, E. W. R. (1988) The influence of CO2 enrichment, phosphorus deficiency and water stress on the growth, conductance and water use of Pinus radiata D.Don. Plant, Cell and Environment, 11, 91-98.
3. Faria, T., Wilkins, D., Besford, R. T., Vaz, M., Pereira, J. S. and Chaves, M. M. (1996) Growth at elevated CO2 leads to down-regulation of photosynthesis and altered response to high temperature in Quercus suber L. seedlings. J. Exp. Botany, 47(304), 1755-1761.
4. Glenn, D. M. and Welker, W. V. (1997) Effects of rhizosphere carbon dioxide on the nutrition and growth of peach trees. HortScience, 32(7), 1197-1199.
5. Gough, R. E. (1994) The highbush blueberry and its management. Food Products Press. An imprint of the Haworth Press, Inc., New York.

6. Hsiao, T. C. and Jackson, R. B. (1999) Interactive effects of water stress and elevated CO2 on growth, photosynthesis, and water use efficiency. In: Luo, Y. and Mooney, H.A. (Eds.), Carbon dioxide and environmental stress. Academic Press. London, 3-7.
7. Kimball, B. A., Kobayashi, K. and Bindi, M. (2002) Responses of agricultural crops to free-air CO2 enrichment. Advances in Agronomy, 77, 293-368.
8. Lawlor, D. W. and Mitchell, A. C. (1991) The effects of increasing CO2 on Crop photosynthesis and productivity: a review of field studies. Plant, Cell and Environment, 14, 807-818.
9. Mearns, L.O. (2000) Climatic change and variability. In: Reddy, K. R. and Hodges, H. F. (Eds.), Climate change and global crop productivity. CAB International. New York, 7-35.
10. Mousseau, M. and Enoch, H. Z. (1989) Carbon dioxide enrichment reduces shoot growth in sweet chestnut seedlings (Castanea sativa Mill.). Plant, Cell and Environment, 12, 927-934.
11. Norby, R. J., O'Neill, E. G. and Luxmoore, R. J. (1986) Effects of atmospheric CO2 enrichment on the growth and mineral nutrition of Quercus alba seedlings in nutrient-poor soil. Plant Physiol., 82, 83-89.
12. Norby, R. J. and O'Neill, E. G. (1989) Growth dynamics and water use of seedlings of Quercus alba L. in CO2-enriched atmospheres. New Phytol., 111, 491-500.
13. Norby, R. J. and O'Neill, E. G. (1991) Leaf area compensation and nutrient interactions in CO_2-enriched seedlings of yellow poplar (Liriodendron tulipifera L.). New Phytol., 117, 515-528.
14. Porter, M. A. and Grodzinski, B. (1984) Acclimation to high CO_2 in bean. Plant Physiol, 74, 413-416.
15. Radoglou, K. M. and Jarvis, P. G. (1990a) Effects of CO_2 enrichment on four poplar clones. I. Growth and leaf anatomy. Annals of Botany, 65, 617-626.
16. Radoglou, K. M. and Jarvis, P. G. (1990b) Effects of CO_2 enrichment on four poplar clones. II. Leaf surface properties. Annals of Botany, 65, 627-632.
17. Radoglou, K. M. and Jarvis, P. G. (1992) The effect of CO_2 enrichment and nutrient supply on growth morphology and anatomy of Phaseolus vulgaris L. seedlings. Annals of Botany, 70, 245-256.
18. Rogers, H. H., Thomas, J. F. and Bingham, G. E. (1983) Response of agronomic and forest species to elevated atmospheric carbon dioxide. Science, 220, 428-429.
19. Scheidegger, U. C. and Nösberger, J. (1984) Influence of carbon dioxide concentration on growth, carbohydrate content, translocation and photosynthesis of white clover. Annals of Botany, 54, 735-742.
20. Sionit, N., Hellmers, H. and Strain, B. R. (1980) Growth and yield of wheat under CO_2 enrichment and water stress. Crop Science, 20, 687-690.
21. Sionit, N. (1983) Response of soybean to two levels of mineral nutrition in CO_2 -enriched atmosphere. Crop Science, 23, 329-333.
22. Tissue, D. T., Thomas, R. B. and Strain, B. R. (1993) Long-term effects of elevated CO_2 and nutrients on photosynthesis and rubisco in loblolly pine seedlings. Plant, Cell and Environment, 16, 859-865.
23. Tolley, L. C., and Strain, B. R. (1984) Effects of CO_2 enrichment and water stress on growth of Liquidambar styraciflua and Pinus taeda seedlings. Can. J. Bot., 62, 2135-2139.

EVALUATION OF SOME NURSERY TECHNIQUES IN THE PRODUCTION OF "KNIP-BOOM" APPLE TREES
DAŽĀDU ĀBEĻU „KNIP-KOKU" VEIDOŠANAS TEHNIKU IZVĒRTĒJUMS

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Kopsavilkums

Divās izmēģinājumu sērijās (2000-2001 un 2001-2002) šķirne 'Sawa' tika potēta uz M.9 EMLA. Klona potcelmi tika atdalīti no mātesauga un potēti dažādos laikos: (1) potcelmi atdalīti novembrī, uzglabāti +1°C, potēti martā, pieauguši 12-15°C temperatūrā 15-20 dienas un izstādīti kokaudzētavā; (2) potcelmi atdalīti decembrī, un turpmākais kā (1); (3) potcelmi atdalīti marta beigās – aprīļa sākumā, potēti un uzreiz izstādīti kokaudzētavā. Otrajā veģetācijas gadā acotņi tika galotņoti 70 cm augstumā, ataugušais centra dzinums apstrādāts ar Arbolin 36 SL un vainags veidots no sasteigtajiem dzinumiem („knip-koku" tehnika). Labākais stādu iznākums bija pielietojot (1) un (2) metodes. Otrā izmēģinājumā trīs stumbru veidošanas metodes tika izmantotas „knip-koku" veidošanā šķirnēm 'Shampion' uz M.9 T339 acotai 2002. gadā un 'Rubin' uz P 59 acotai 2003. gadā. Pilnīga sānzaru izgriešana, atstājot tikai jaunizveidoto centrālo dzinumu, prasīja mazāk darbaspēka ieguldījuma nekā sānzaru galotņošana un vēlāka izgriešana. Stādu kvalitāte neatšķiras.

Abstract

In two experimental series (2000-2001 and 2001-2002) 'Sawa' was bench grafted on M.9 EMLA. Rootstocks were separated from mother plants at different dates and grafts treated in a different way: (1) rootstocks taken from stoolbeds in November, stored at +1°C, grafted in March, callused at 12-15°C for 15-20 days and then planted in the nursery; (2) rootstocks separated in December, then treated as (1); (3) rootstocks separated at the end of March or beginning of April, grafted and planted directly in the nursery. In the second year scion shoots were headed back at 70 cm, the renewed leader treated with Arbolin 36 SL and the crown formed by sylleptic shoots ("knip-boom" method). The higher output of nursery trees was obtained from the treatments (1) and (2), when rootstocks were separated in autumn or winter and grafts callused. In another experiment, three methods of cleaning stems were compared in production of „knip-boom" trees developed from budding, using 'Šampion' on M.9 T339 in 2002 and 'Rubin' on P 59 in 2003. The complete cleaning of stems and leaving a single renewed leader at once required less labour than successive cleaning with or without pinching of additional sprouts, left temporarily on the stem. Quality of trees produced by either method was similar.

Key words: apple, two-year-old trees, knip-boom trees, bench grafting, callusing, stem cleaning

Introduction

The use of two-year-old trees for establishing intensive apple orchards results in early bearing (Merezhko, 1985; Bootsma and Baart 1990; Włodarczyk 1994, Sadowski *et al*., 2000, Bielicki *et al*., 2002, 2004). Two-year-old trees may be produced in a different ways (Sadowski and Górski, 2003). Nowadays, two-year olds with a renewed leader and feathers (sylleptic laterals), commonly named in Dutch as "knip-boom", are preferred (Bootsma, 1995; Bielicki *et al*., 2004). Such trees not only provide early and high production, but also their growth in the orchard may be more easily controlled (Balkhoven-Baart *et al*., 2000).

The production of "knip-boom" trees involves application of various treatments in the nursery. Bench grafting of scion cultivar on a rootstock in the wintertime provides an opportunity of shortening the nursery cycle to two years (Sadowski and Górski, 2003). In this study different timing of taking rootstocks assigned for grafting and of different treatment of grafts was evaluated. In the other experiments different methods of stem cleaning, in the process of training of a new leader (after heading back a scion shoot), were compared.

Materials and Methods

Two different nursery trials were carried out in Warsaw-Wilanów, Central Poland, each in two series. Soil of the site was silty loam alluvial, rich in humus.

T r i a l 1. Sawa apple cultivar was grafted on M.9 EMLA rootstocks 9-11 mm in diameter, at 20 cm above root collar. Rootstocks used were separated from the mother plants at different dates and grafts treated in a different way: (1) rootstocks separated from mother plants at the beginning of November, stored in cold storage at +1°C, grafted in March, subjected to callusing (heat pre-treatment) at 12-15°C for 15-20 days, followed by storage at 1°C for 5-7 days and then planted; (2) rootstocks separated in the second half of December, then treated as (1); (3) rootstocks separated at the end of March or beginning of April, grafted and immediately planted in the nursery. In the 2nd year of nursery (2001 or 2002) scion shoots were headed back at 70 cm, the renewed leader treated with Arbolin 36 SL (branching promoter, BA + GA_3) and crown formed of sylleptic shoots ("knip-boom" method).

Both experimental series were set in a randomised block design, with 6 replications and 30 plants per plot. Before digging out the trees (in autumn 2001 and 2002) stem diameter at 35 cm, tree height and length of lateral shoots were recorded. In the series I tree height was also measured after the 1st year (in autumn 2000). The total output of trees and output of branched trees was also calculated.

T r i a l 2. Both experimental series of this trial were carried out on trees produced in the three-year nursery cycle, where scion shoot was developed in the 2nd year of nursery – from budding performed in the 1st year. In the 3rd year, this scion shoot was headed back at 70 cm and the renewed leader was treated with Arbolin 36SL, when it reached the length of 25-35 cm above the cut, at the end of May. All suckers bursting from the rootstock were removed as they appeared.

Needless scion sprouts, appearing on the stem after cutting were eliminated in a different way: (1) all sprouts (except for one, which was assigned for a renewed leader) were removed at once when they had 3-5 leaves; (2) sprouts appearing at the basal, 40-cm part of the stem and 2-3 upper sprouts, competing with the leader, were removed at once, whereas the remaining ones (4-7) were left temporarily for a period of ca 3 weeks and finally removed 2-3 days before the Arbolin treatment; (3) the same as (2) + pinching of the tips of temporary sprouts.

The first series of this trial was carried out on 'Šampion' on M.9 T339 rootstock, with experimental treatments performed in 2002, the second series on 'Rubin' on P 59, with treatments in 2003. Both series were set in a randomised block design, with 5 replications and 21-24 trees per plot. Stem diameter and length of lateral shoots were measured before digging, as in the trial 1. Additionally, the length of the renewed leader was measured before treating it with Arbolin. Time spent on cleaning of stems by different methods was also recorded.

Results of measurements of both trials were elaborated by analysis of variance, separately for each experimental series. Significance of differences between treatment means was estimated using the Newman-Keuls test, at $\propto$=0.05. Data related to the output of trees and to the time spent on the cleaning of stems in the trial 2 were not subjected to statistical analysis.

Results

T r i a l 1. As expected, rootstocks taken from the stoolbeds in April had mature (brown) roots, while rootstocks taken in November or even in December had a high proportion of white, delicate roots, which could be easily damaged while handling. In series I the output of trees was high, irrespective of the date of taking rootstocks and the treatment of grafts (Table 1). In series II a considerably lower output of trees was obtained when rootstocks were taken in April, immediately grafted and planted without callusing grafts. A low percentage of branched trees was also noted in this treatment.

Table 1. Output of trees, 'Sawa' on M.9 EMLA, % in relation to the grafts planted

Date of taking rootstocks	Date of grafting	Treatment of grafts	Series I (2000-2001)		Series II (2001-2002)	
			total	branched	total	branched
November	March	callusing	93.0	88.9	86.4	79.5
December	March	callusing	97.2	92.8	85.7	72.6
April	April	planting at once	97.2	94.4	78.6	52.6

In series I, after the 1st year, significantly lower trees were obtained, when grafting was made on rootstocks taken in April and non-callused (treatment 3) than with grafting in March on rootstocks taken in November or December and callused before planting (treatment 1 or 2) – Table 2. After the 2nd year these differences were effaced and no significant differences due to treatment were noted in this series in the final height or in the stem diameter of two-year-olds. In series II there were no differences in the final tree height. However, trees obtained from grafts made on rootstocks taken in April and non-incubated were definitely thinner. Trees coming from grafts made on rootstocks taken in December were slightly thinner than made on rootstocks taken in November.

Table 2. Indices of tree size, 'Sawa' on M.9 EMLA

Date of taking rootstocks	Date of grafting	Treatment of grafts	Series I (2000-2001)			Series II (2001-2002)	
			one-year-olds	two-year-olds		two-year-olds	
			height, cm	height, cm	diameter, mm	height, cm	diameter, mm
November	March	callusing	117 b [1]	166 a	14.8 a	166 a	14.2 c
December	March	callusing	115 b	166 a	14.4 a	166 a	13.0 b
April	April	planting at once	105 a	163 a	14.3 a	163 a	11.8 a

[1] Mean values marked with the same letters (within the columns) are not significantly at different (at $\propto$=0.05).

No significant differences in the number or length of lateral (sylleptic) shoots were found in the series I of this trial (Table 3). In series II the lowest number of lateral shoots and the smallest total length of laterals was obtained with grafting on rootstocks taken in April and non-callused grafts, while the highest indices of branching were noted with grafting in March on rootstocks taken in November and grafts callused.

Table 3. Indices of lateral shoots, 'Sawa' on M.9 EMLA

Date of taking rootstocks	Date of grafting	Treatment of grafts	Shoot number per tree			Total shoot length, cm	Mean shoot length, cm
			<20 cm	≥20 cm	total		
Series I (2000-2001)							
November	March	callusing	1.5 a	4.2 a	5.7 a	253 a	46.2 a
December	March	callusing	1.3 a	3.9 a	5.2 a	230 a	46.9 a
April	April	planting at once	1.4 a	4.0 a	5.4 a	234 a	44.9 a
Series II (2001-2002)							
November	March	callusing	1.2 a	4.3 b	5.5 b	248 b	47.1 a
December	March	callusing	1.2 a	3.5 a	4.7 ab	203 ab	45.2 a
April	April	planting at once	0.9 a	3.2 a	4.1 a	175 a	45.3 a

Trial 2. Immediate removal of all additional sprouts from stems (treatment 1) was the least laborious in both series of trials (Table 4).

Table 4. Time spent on cleaning of stems from additional sprouts, per 100 trees

Treatment of temporary sprouts on the stem	Date and time of cleaning			
	first cleaning	correction	final cleaning	total
Series I – 'Šampion' on M.9 T 339 – 2002				
	08.05	20.05	24.05	
Complete cleaning of all additional sprouts at once	19' 30"	1' 25"	2' 55"	23' 50"
Successive cleaning of additional sprouts	14' 30"	7' 15"	20' 15"	38' 40"
Successive cleaning with pinching of sprouts left	24' 40"	7' 15"	17' 25"	49' 20"
Series II – 'Rubin' on P 59 – 2003				
	10.05	21.05	28.05	
Complete cleaning of all additional sprouts at once	12' 30"	5' 30"	4' 10"	22' 10"
Successive cleaning of additional sprouts	13' 50"	6' 55"	5' 35"	26' 20"
Successive cleaning with pinching of sprouts left	24' 20"	8' 20"	5' 30"	38' 10"

The most laborious was successive cleaning of stems with additional pinching of tips of the temporarily left sprouts (treatment 3). Only in series II the new leader, developed after heading back of scion shoot (maiden tree) in the 3rd year of nursery, was shorter when the complete cleaning of stem was applied at once (Table 5). However, this has not affected the final quality of two-year-old "knip-boom" trees (Table 5 and 6). A slightly smaller number of lateral shoots, resulting from the treatment 2, was noted in the series II (Table 6).

Table 5. Length of the renewed leader \1 and indices of the final tree size

Treatment of temporary sprouts on the stem	Length of new leader\1 , cm	Tree height, cm	Stem diameter, cm
Series I – 'Šampion' on M.9 T 339 – 2002			
Complete cleaning of all additional sprouts at once	26.0 a	168 a	14.6 a
Successive cleaning of additional sprouts	26.6 a	166 a	14.7 a
Successive cleaning with pinching of sprouts left	27.2 a	167 a	14.9 a
Series II – 'Rubin' on P 59 – 2003			
Complete cleaning of all additional sprouts at once	23.7 a	171 a	16.2 a
Successive cleaning of additional sprouts	28.3 b	175 a	15.9 a
Successive cleaning with pinching of sprouts left	28.2 b	173 a	15.8 a

\1 before treatment with Arbolin 36SL

Table 6. Indices of lateral shoots

Treatment of temporary sprouts on the stem	Shoot number per tree			Total shoot length, cm	Mean shoot length, cm
	<20 cm	≥20 cm	total		
Series I – 'Šampion' on M.9 T 339 – 2002					
Complete cleaning of all additional sprouts at once	6.5 a	5.9 a	12.4 a	309 a	25.4 a
Successive cleaning of additional sprouts	5.0 a	6.3 a	11.3 a	312 a	26.9 a
Successive cleaning with pinching of sprouts left	5.7 a	6.0 a	11.7 a	332 a	27.7 a
Series II – 'Rubin' on P 59 – 2003					
Complete cleaning of all additional sprouts at once	5.1 a	3.4 a	8.5 b	161 a	18.8 a
Successive cleaning of additional sprouts	4.7 a	2.8 a	7.5 a	135 a	17.8 a
Successive cleaning with pinching of sprouts left	5.1 a	3.4 a	8.5 b	164 a	18.6 a

Discussion

Under the weather conditions of Central Poland, vegetative rootstocks may be taken from the stoolbeds either in late autumn or in spring, as in the wintertime the ground is usually frozen. Only during occasional periods of thawing it is possible to take rootstocks from stoolbeds in mid-winter, as happened in the trial 1 in December 1999 and 2000. The roots of rootstocks taken in autumn are immature, white and delicate, and may be easily damaged while handling, in contrast to the roots of rootstocks taken in spring. Hence, it was assumed that taking rootstocks in spring might result in a better survival and growth of trees. On the other hand, in the process of production of trees from bench grafting, a heat pre-treatment of grafts for a period of 2-3 weeks is usually recommended, in order to stimulate formation of the *callus* and in consequence a better take of grafts; this treatment is commonly named "callusing". For callusing, grafting must be performed at the beginning of March and for this purpose rootstocks should be taken in autumn and cold stored. Callusing is impossible when rootstocks are taken from stoolbeds in spring, as then it is too late for the heat pre-treatment, grafts must be planted immediately. The results of the experiments carried out within our trial 1 did not confirm the original hypothesis. Although rootstocks taken in spring had mature roots, grafts made on them resulted in the same or lower output and in a similar or lower final tree quality. Apparently callusing of grafts was a decisive factor for success of bench grafting, as indicated in the study of Włodarczyk and Grzywaczewski (1994).

It is worth noting that, in general, satisfactory results were obtained with bench grafting. This is in line with the results of Sadowski and Górski (2003), who have shown that "knip-boom" two-year-old apple trees produced in a 2-year nursery cycle may not be inferior to "knip-boom" trees produced from budding – in a 3-year cycle.

The techniques of cleaning stems in the process of formation of a new leader for a “knip-boom” tree has not been referred in the special literature. According to the common opinion of nurserymen, immediate complete cleaning of stems of the needless sprouts is not desirable, as some leaves are needed to feed the stem with assimilates until the new leader develops an adequate number of leaves. The results of the trial 2 have shown that this is not necessary. Although in series II of this trial the renewed leader was slightly weaker when the complete cleaning of stem was applied at once, this had not any significant effect on the final tree quality. Apparently, considering a slightly weaker initial growth of the renewed leader, application of a branching promoter (Arbolin) should be delayed by few days when the method of immediate complete cleaning of stems is applied. On the other hand, a lower labour expense is an important advantage of this method.

Conclusions

Vegetative apple rootstocks assigned for bench grafting should be taken from stoolbeds in autumn, because then they can be grafted in March and subjected to callusing before planting. Planting of non-callused grafts may result in inferior results.

In the process of formation of the new leader of “knip-boom” trees, temporary leaving additional sprouts on the stem is not needed. Immediate complete cleaning of stems is less laborious and results in the same tree quality.

References

1. Balkhoven-Baart J.M.T., Wagenmakers P.S., Bootsma J.H., Groot M.J. and Wertheim S.J. (2000) Development in Dutch apple planting. Acta Hort., 513, 261-269.
2. Bielicki P., Czynczyk A.and Nowakowski S. (2002) Influence of plant material quality on growth and yield of two apple cultivars. Scientific Works of the Lithuanian Institute of Horticulture and Lithuanian University of Agriculture, Horticulture and Vegetable Growing, 21 (4), 33-38.
3. Bielicki P, Czynczyk A. and Nowakowski, S. (2004) Wzrost i owocowanie jabłoni odmiany 'Szampion' w zależności od jakości użytego materiału szkółkarskiego. Folia Universitatis Agriculturae Stetinensis-Agricultura, 96, 21-24.
4. Bootsma J. (1995) Plantmateriaal appel. Voorsprong met tweejarige bomen. Fruitteelt (Den Haag), 85 (47), 16-17.
5. Bootsma J. and Baart J. (1990) Keuze voor halfprodukten is niet gerecht. Fruitteelt (Den Haag), 80 (47), 22-23.
6. Merezhko Yu. (1985) Kachestvo posadochnogo materiala i urozhainosť yabloni. Plodoovoshchnoe Khozyaĭstvo, 9, 31-32.
7. Sadowski A. and Górski M. (2003) Quality of apple planting stock depending on its method of production. Rastenyev’dni Nauki / Plant Science (Sofia), 11 (5), 394-398.
8. Sadowski A., Słowiński A. Dominiak R. and Kuras M. (2000) Quality of planting stock and productivity of apple trees. In: Kaufmane E., Libek A. eds, Proc. Intern. Conf. Fruit Production and Fruit Breeding, Tartu University Press, Estonia, 37-41.
9. Włodarczyk P. (1994) Wpływ jakości wysadzonych drzewek na wzrost i plonowanie jabłoni Elstar na podkładce M 9. Szkółkarstwo (Numer Specjalny), 38-39.
10. Włodarczyk P. and Grzywaczewski P. (1994) Wpływ trzech czynników na ilość i jakość drzewek jabłoni odmiany Jonagold szczepionych "w ręku". Annales Universitatis Mariae Curie-Sklodowska, Sectio EEE,-Horticultura. 2, 51-58.

THE PROPAGATION OF CURRANTS AND GOOSEBERRIES BY SOFTWOOD AND COMBINED CUTTINGS
UPEŅU, JĀŅOGU UN ĒRKŠĶOGU PAVAIROŠANA IZMANTOJOT LAPAINOS UN DAĻĒJI KOKSNAINOS SPRAUDEŅUS

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Kopsavilkums

Lietuvas Dārzkopības Institūtā (2002. - 2003.) tika veikta upeņu, sarkano jāņogu, zelta jāņogu un ērkšķogu pavairošana lietojot lapainos un daļēji koksnainos spraudeņus. Spraudeņus apstrādāja ar β-indoliletiķskābes (IES), IES ar askorbīnskābi, un naftiletiķskābes (NES) šķīdumiem. Vislielākais apsakņojušos stādu iznākums bija upeņu (75.2 %) un ērkšķogu (72.9 %) lapainajiem spraudeņiem, pielietojot 20 stundu mērcēšanu IES šķīdumā 50 mg l^{-1} koncentrācijā. Sarkanajām un zelta jāņogām tika iegūti sliktāki apsakņošanās rezultāti. Sarkano jāņogu lapaino spraudeņu apsakņošanās variēja starp 33.3 - 50.0 %, bet zelta jāņogas - 42.9 - 54.2 %. Daļēji koksnaino spraudeņu apsakņošanās šīm sugām bija 36.8 %. Labākās kvalitātes spraudeņi iegūti izmantojot NES šķīdumu. *Ribes* ģints dažādu sugu spraudeņi apsakņojās atšķirīgi.

Abstract

Rooting in artificial mist of black (*R. nigrum* L.), red (*R. rubrum* L.), golden (*R. aureum* Pursh.) currant and gooseberry (*R. uva-crispa* L.) softwood and combined cuttings, affected by β-indoleacetic acid (IAA), mixture of IAA and ascorbic acid, and naphthaleneacetic acid (NAA) solutions, were studied at the Lithuanian Institute of Horticulture in 2002-2003. The biggest output of rooted plants was obtained from black currants and gooseberries. All applied growth stimulators increased the rooting of black currants softwood cuttings, and the rooting of the same cuttings of gooseberries was increased only by IAA. The best percent of rooted softwood cuttings of black currants (75.2) and gooseberries (72.9) was obtained when before the rooting these cuttings for 20 hours were affected by IAA 50 mg l^{-1} water solution. The rooting of softwood cuttings of red and golden currants was worse that this of gooseberries and black currants. Depending on growth stimulator, the rooting of softwood cuttings of red currants on the average reached 33.3-50.0%, of golden currants – 42.9-54.2%, and of combined cuttings of these cultivars – 36.8%. The best quality of rooted cuttings was obtained using NAA solution. The rooting and quality of softwood and combined cuttings mostly depended on *Ribes* cultivar.

Key words: currants, gooseberries, propagation, stimulators, cuttings

Introduction

Lithuanian agroclimatic conditions are favourable for black currant and gooseberries growing. For the propagation of plants generative (by seeds) and vegetative (by root shoots, vertical and horizontal layers, woody and softwood cuttings, grafts and eyes) methods may be applied. In the practice of horticulture black currant and gooseberries are propagated by woody and softwood cuttings (Czynczyk, 1998).

Many factors determine the rooting of plants, the most important are as follow: biological properties of plant variety, healthiness and environmental conditions (Staniene *et al.*, 2004). It was showed that the intensivity of rooting is determined by the chemical structure and concentration of the growth stimulator (Novickiene and Darginaviciene, 2001; Novickiene *et al.*, 2004; Turetskaja and Polikarpova, 1968).

The aim of the investigation was to establish the influence of growth stimulators on the rooting of softwood and combined cuttings of black, red, golden currants and gooseberries and on the quality of rooted cuttings propagating these plants in the artificial mist.

Materials and Methods

In 2002-2003 at the Institute of Lithuanian Horticulture black currant cvs. 'Joniniai' (Lithuania), 'Titania' (Sweden) and 'Minay Shmyriov' (Belarus), red currant cvs. 'Rondom' (The Netherlands) and 'Werdavia' (Germany), golden currant cvs. 'Corona' (Germany), 'Brekht' (Germany) and selection number AuG-1 (Lithuania) and gooseberry cvs. 'Nesluchovskyj' (Ukraine), 'Kirdeikiai' (Lithuania) and 'Kursu Dzintars' (Latvia) were investigated.

The shoots were taken from selection nursery at the last decade of June, while the plants were actively growing. Softwood and combined (softwood +0.5 cm of last year wood) cuttings were obtained from 2-3 internodes (9-14 cm long). The influence of growth stimulators on softwood and combined plants were investigated according following scheme: 1) control (H_2O), 2) IAA (50 mg l^{-1}), 3) IAA +ascorbic acid (50 mg l^{-1} +0.25 g l^{-1}), 4)NAA (25 mg l^{-1}).

32 softwood and combined cuttings were prepared for each variant. The bottom part of cuttings (1 cm) was soaked for 20 hours in water or solutions of growth stimulators. Then they were planted in substrate (2 parts of peat and 1 part of sand) of artificial mist at distances of 5x5 cm. Cuttings of each variant were grown in four replications by randomized block design. In the second half of September the rooted cuttings were replanted in an unheated greenhouse at distances of 20x20 cm. Before planting their quality was evaluated according to the original 5 scores scale (1 – the length of the main roots up to 4 cm and 1 full leaf is remained, 2 – the length of the main roots 4-8 cm and 3 full leaves are remained, 3 – the length of the main roots 8-12 cm and new shoots up to 1 cm in length are grown, 4 – the length of the main roots 12-16 cm and new shoots up to 1-4 cm in length are grown, 5 – the length of the main roots more than 20 cm and new shoots more than 4 cm in length are grown).

All data were subjected to analysis of variance. The significance of differences between the cultivars was estimated at a level of 0.05 (Manly, 1994).

Results

R o o t i n g o f p l a n t s**.** Softwood and combined cuttings of black, red, golden currants and gooseberries affected by the growth stimulator rooted in the artificial mist during 20-25 days. Black currants rooted most quickly, and gooseberries were the latest.

The percent of the rooted cuttings depended on the cultivar of cultivar *Ribes* and growth stimulator (Table 1). The rooting of black currant softwood cuttings affected by growth stimulator reached 53.1-78.1%, and in control variant (soaked only in water) – 44.4-62.5%. The percent of combined cutting rooting was higher. Combined cuttings of control variant cv. 'Joniniai' rooted best of all.

The influence of growth stimulators on the both cultivars of red currants was insignificant. The rooting of softwood cuttings reached up to 50.0% and the rooting of combined cuttings – up to 41.6%. The addition of ascorbic acid into IAA solution improved the rooting both of softwood and combined cuttings. The rooting of combined cuttings of cv. 'Rondom' was better then this of cv. 'Werdavia'. From 4 investigated variants, in 3 variants softwood cuttings of cv. 'Rondom' rooted better than combined cuttings.

Growth stimulators differently affected the rooting of cuttings of the investigated golden currant cultivars. After the effect by the growth stimulator up to 28.5-71.9% of softwood cuttings took roots. Combined cuttings rooted better (62.5%) in the control variant. In all cases, growth stimulators improved the rooting of selection number AuG-1 cuttings. Growth stimulators almost didn't influence the cuttings of cv. 'Breckt', but they increased the rooting of cutting cultivar 'Corona'.

Growth stimulators differently affected the rooting of gooseberry cuttings also. They decreased the rooting of cutting cv. 'Nesluchovskyj', and the amount of rooted cutting cv. 'Kursu Dzintars' significantly increased. The addition of ascorbic acid into all solutions of growth stimulators improved the rooting of combined cuttings of investigated cultivars. The rooting of combined cuttings 'Kursu Dzintars' affected by IAA solution enriched with ascorbic acid reached even 96.9%. The comparison of the rooting of gooseberry softwood and combined cuttings showed that combined cuttings rooted significantly better.

T h e q u a l i t y o f t h e r o o t e d c u t t i n g s . Growth stimulators most often improved the quality of softwood cuttings, but worsened the quality of combined cuttings (Table 2).

Table 1. The influence of growth stimulators on the rooting of currant and gooseberry cuttings

Cultivars		The amount of rooted cuttings (%)							
		Control (H_2O)		IAA		IAA + ascorbic acid		NAA	
		SWC*	CC**	SWC	CC	SWC	CC	SWC	CC
Blackcurrants	'Joniniai'	53.1	96.9	68.8	81.2	53.1	75.0	56.2	62.5
	'Titania'	44.4	68.8	70.5	56.2	53.1	37.5	62.5	41.7
	'Minay Shmyriov'	62.5	78.1	78.1	75.0	71.9	62.5	56.2	62.5
	LSD_{05}	18.0	21.9	17.4	23.1	18.4	22.8	18.8	20.6
Red currants	'Rondom'	41.7	40.6	33.3	37.5	41.6	40.6	50.0	31.2
	'Werdavia'	-	24.0	-	25.0	-	28.8	-	28.1
	LSD_{05}		15.5		12.1		10.1		8.0
Golden currants	'Breckt'	53.1	62.5	53.1	30.9	62.5	31.2	53.1	25.0
	'Corona'	65.6	31.2	71.9	21.9	68.8	28.1	40.6	19.4
	AuG-1	26.1	16.7	28.5	35.4	31.2	20.4	35.1	21.5
	LSD_{05}	20.7	12.4	17.9	13.2	17.4	10.6	15.8	16.2
Gooseberries	'Nesluchovskyj'	62.5	81.2	65.6	65.6	37.5	78.1	43.8	65.6
	'Kirdeikiai'	71.9	84.4	75.0	68.8	56.2	90.6	56.2	59.4
	'Kursu Dzintars'	75.0	84.4	71.1	93.8	78.1	96.9	78.1	87.5
	LSD_{05}	18.7	21.3	11.6	18.7	18.5	12.5	21.3	20.2

*- Softwood cuttings ** - Combined cuttings

Table 2. The influence of growth stimulators on the quality of cuttings of currants and gooseberries rooted in the artificial mist

Cultivars		The quality of rooted cuttings (scores)							
		Control (H_2O)		IAA		IAA + ascorbic acid		NAA	
		SWC*	CC**	SWC	CC	SWC	CC	SWC	CC
Blackcurrants	'Joniniai'	2.8	3.3	3.0	3.0	3.2	2.8	2.9	2.7
	'Titania'	3.3	3.4	3.5	3.2	2.8	3.1	3.3	3.1
	'Minay Shmyriov'	3.0	3.2	3.4	3.1	2.8	3.0	3.9	3.0
	LSD_{05}	0.8	1.1	0.5	0.7	0.4	0.5	0.9	0.6
Redcurrants	'Rondom'	1.0	1.2	1.0	1.0	1.5	1.1	1.2	1.5
	'Werdavia'	-	1.0	-	1.0	-	1.0	-	1.0
	LSD_{05}		0.4		0.1		0.3		0.4
Golden currants	'Breckt'	2.1	1.7	2.1	1.6	2.8	3.0	2.1	2.0
	'Corona'	3.1	1.5	3.2	1.4	2.9	1.9	3.5	3.5
	AuG-1	2.6	1.1	2.9	1.4	2.6	1.8	2.0	1.6
	LSD_{05}	0.9	0.6	0.8	0.6	0.5	0.9	1.1	0.6
Gooseberries	'Nesluchovskyj'	2.6	3.2	3.2	3.0	3.4	3.0	2.1	3.5
	'Kirdeikiai'	2.2	2.9	4.0	4.1	2.5	3.3	3.5	3.6
	'Kursu Dzintars'	2.7	2.8	3.5	4.3	2.8	3.5	2.6	3.5
	LSD_{05}	0.8	0.8	0.6	1.1	0.8	0.5	0.8	0.6

*- Softwood cuttings ** - Combined cuttings

Various growth stimulators differently affected the softwood cuttings of the investigated cultivars. The best quality was of rooted softwood cuttings of cv. 'Joniniai' IAA +ascorbic acid (3.2 scores), cv. 'Titania' – IAA (3.5 scores), and cv. 'Minay Shmyriov' – NAA (3.9 scores) under the effect of solutions. The best quality (3.2-3.4 scores) of combined cuttings of all investigated black currant cultivars was in the control variant.

Growth stimulators almost did not improve the quality of both softwood and combined red currant cuttings (1.0-1.5 scores). The best quality of softwood cuttings (1.5 scores) was obtained under the effect of IAA + ascorbic acid solutions.

All the investigated growth stimulators improved the quality of rooted golden currant cuttings. Both softwood and combined cuttings of cultivar ‘Corona’ were of best quality (3.5 scores) when affected with NAA solution, and cuttings of cv. ‘Breckt’ – affected with solutions of IAA + ascorbic acid (respectively 3.2-2.8 scores). The quality of cuttings of cvs. ‘Breckt’ and ‘Corona’ in most investigated variant was better than the quality of cuttings of selection number AuG-1.

From all the investigated varieties of *Ribes*, growth stimulators significantly increased the amount of the rooted gooseberry cuttings and their quality. The rooted cuttings of cvs. ‘Kirdeikiai’ and ‘Kursu Dzintars’ were of best quality (3.5-4.3 scores) and significantly better than the cuttings of cv. ‘Nesluchovskyj’ (2.1-3.4 scores). The evaluation of all rooted softwood and combined cuttings of gooseberry cultivars showed that in most cases combined cuttings were of best quality.

Discussion

Many berry plants (*Ribes*, *Rubus*, *Vaccinium*, *Hippophae*) may be propagated by softwood cuttings (Abolins *et al.*, 2003; Coorts, Hull, 1972; Czynczyk, 1998). Black and red currants most often are propagated by woody cuttings, but the propagation by softwood cuttings is used also in order to propagate new cultivars quickly. By this propagation method *Cecidophyopsis ribis* free blackcurrant material is obtained (Jermakov, 1981). This method is the most important in gooseberry propagation (Czynczyk, 1998). The data of our investigations showed that combined cuttings of gooseberries rooted best of all and this partly coincided with the results obtained in Russia (Sergejeva, 1989). Nowadays the interest in *R. aureum* is increasing. They are used as rootstock in currant and gooseberry growing and berry production. The investigations about the propagation of golden currants by softwood cuttings are not abundant.

In our investigation all cuttings planted in unheated greenhouse survived the winter and grew on. The further growth of bushes mostly depended on root the quality of the rooted cuttings. Growth stimulators increased the rooting of black currant softwood cuttings and decreased the rooting of combined cuttings. It is best of all to propagate in the artificial mist red and golden currants by softwood cuttings, gooseberries – by combined cuttings, and black currants – both by softwood and combined cuttings.

Conclusions

The biggest amount of rooted softwood cuttings of black currants (75.2%) was obtained, when they were affected by 50 mg l^{-1}, red currants (50.0%) - NAA (25 mg l^{-1}), golden currants (54.2 %) and gooseberries (72.9 %) - IAA + ascorbic acid (50 mg l^{-1} + 0.25 g l^{-1}) solutions. Gooseberry combined cuttings rooted best of all (70.8-88.5%), and the combined cuttings of currants rooted worse than softwood cuttings.

The best quality of rooting of currant and gooseberry cuttings was obtained with the solution NAA (25 mg l^{-1}). The rooting and quality of softwood and combined cuttings mostly depended on *Ribes* cultivar.

References

1. Abolins M., Liepniece M. and Gurtaja L. (2003). Propagation of highbush blueberries by softwood cuttings in Latvia. Horticulture and vegetable growing, 22 (2), 65-73.
2. Coorts G. D. and Hull J. W. (1972). Propagation of highbush blueberry (Vacinium corymbosum) by hard- and softwood cuttings. Plant propagator, 18, 9-12.
3. Czynczyk A. (1998). Szkolkarstwo sadownice, Warszawa, Pantstwowie wydawnictwo rolnicze i Lesnie, 222.
4. Jermakov B. S. (1981). Propagation of top and small plants by softwood cuttings. Kisinev, Stiinca, 224. (in Russian).
5. Manly B. F. J. (1994). Multivariate statistical methods. London, Chapman and Hall, 214.
6. Novickiene L. and Darginaviciene J. (2001). The course of morphogenetic processes in the rooting of green cherry cuttings. Horticulture and vegetable growing, 20 (3), 160-175.

7. Novickiene L., Darginaviciene J. and Maksimov G. (2004). Root initiation and development by auxin in physiological analogue TA-12. Acta Universitatis Latviensis, Biology, 676, 201-206.
8. Sergejeva K. D. (1989). Gooseberry. Moscow, Agropromizdat, 208. (in Russian).
9. Staniene G., Siksnianas T. and Stanys V. (2004). Retesniuju sodo augalu dauginimas auginiais *in vitro*. Horticulture and vegetable growing, 23 (1), 3-9.
10. Turetskaja R. C. and Polikarpova F. J. (1968). Vegetative propagation of plants with application of growth stimulators. Moscow, Nauka, 91. (in Russian).

INCOMPATIBILITY PROBLEMS IN SWEET CHERRY TREES ON DWARFING ROOTSTOCKS
SALDO ĶIRŠU NESADERĪBA AR PUNDURPOTCELMIEM

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Kopsavilkums

Potcelmu un potzaru nesaderība ir sen zināma problēma dārzkopībā. Dažām sugām tā ir nopietna problēma. Parasti lietotajiem *Cerasus mahaleb* potcelmiem nav problēmu ar šķirņu saderību. Savādāk ir, ja potcelms ir *Prunus* ģints hibrīds vai atšķirīgs no *P. avium* sugas, kā tas ir saldo ķiršu pundurpotcelmiem. Šajā gadījumā jāveic potcelma un šķirnes saderības pētījumi pirms to ieviešanas praksē. Pārskats par dažiem pētījumiem šajā jomā ir apkopots rakstā. Te arī minētas hipotēzes, kas skaidro saderības trūkumu.

Abstract

The problem of incompatibility between rootstock and scion in horticulture has existed ever since grafting and budding were first employed. Some of the fruit tree rootstocks produce a very good junction with top varieties, but with some others the effectiveness of budding is very low. Usually, there are no problems with the growth or cropping of sweet cherry trees on the Mazzard rootstock. In that case, "compatibility" between the two partners is good. However, this may be different when the rootstock is a hybrid of the *Prunus* species or a selection of other than *P. avium Prunus* species. Most of the dwarfing rootstocks for sweet cherry trees are hybrids and because of the likelihood of incompatibility, the introduction of them to practice should be preceded by detailed investigations of the compatibility between the two graft components. Otherwise, neither the nurseryman nor the fruit grower will be satisfied. A review of some publications with the results of studies on the physiological incompatibility between scions and the best known cherry dwarfing rootstocks, as well as hypotheses that try to explain the lack of or reduced compatibility between joined components are presented in the article.

Keywords: Sweet cherry, rootstock, cultivar, scion-rootstock incompatibility

Introduction

Rootstocks have been used as a means of propagating fruit trees for at least two thousand years. The history of seedling rootstocks is longer than that of clonal, i.e. vegetatively propagated rootstocks. Among the dwarfing rootstocks the first to be discovered were rootstocks for apple trees. Dwarfing rootstocks for sweet cherry trees have proved much more difficult to breed and it is only in the last years that they have been introduced to commercial orchards (Webster, 2004). At the Fruit Research Station in East Malling, England, the collection of cherry rootstocks started in 1914 with the aim of eliminating the variability through vegetative propagation and to study the effects of clonal rootstocks on scion performance. This work resulted in the release of Mazzard rootstock 'F 12/1' (*P. avium*) that could be propagated vegetatively. 'F 12/1' performed as very vigorous rootstock. According to the Report of East Malling Research Station, 'Colt' (*P. avium* x *P. pseudocerasus*), bred in 1958, had for many years been regarded and marketed commercially as the first rootstock for the sweet cherry, providing some control of tree vigour (Tydeman and Garner, 1966; Webster, 1996). However, numerous experiments, some of them also conducted in Poland, have not confirmed that 'Colt' gives smaller trees in comparison with the clonal or seedling Mazzard rootstocks - trees on 'Colt' were similar in size or even more vigorous (Grzyb *et al.*, 1998; Sitarek *et al.*, 1999). The first results on really dwarfing rootstocks for sweet cherry trees were published in 1970s. At this time breeding programs on new sweet cherry rootstocks were being realized in Europe and the USA (Wertheim, 1998). New dwarfing and semi-dwarfing rootstocks, presently evaluated in many countries and already used in practice, may change sweet cherry production. Fruit trees of small sizes are easier and cheaper to manage, crop more precociously and productively and often bear fruits of higher quality than the traditional large trees. In addition, dwarf trees would also allow the use of plastic roofs to protect fruits from rain-induced cracking as well as nets covering the trees to protect them from damage caused by birds (Balmer, 1998; Meland and Skjervheim, 1998; Sitarek *et al.*, 1999; Webster, 1998). However, most of the dwarfing rootstocks for sweet cherry trees are hybrids of some *Prunus* species, and *Prunus* is a very large genus that comprises many species (Webster and Schmidt, 1996; Wertheim, 1998). Sweet cherry cultivars grafted on rootstocks of different genetic origins may lead to incompatibility problems (Factea *et al.*, 1996; Stehr, 1998; Sitarek and Grzyb, 1998; Webster and Schmidt, 1996; Wertheim *et al.*, 1998).

The aim of this paper is to describe, briefly, incompatibility problems in sweet cherry trees grafted on dwarfing rootstocks. This short article reviews some publications with the results of studies on physiological incompatibility between scions and the best known cherry dwarfing rootstocks as well as hypotheses that try to explain the lack of or reduced compatibility between joined components.

The best known dwarfing rootstocks for sweet cherry trees

The GiSelA series

In the period 1965-1971, an elaborate crossing programme was carried out at the University in Giessen, Germany, involving four different *Prunus* species – *P. avium, P. fruticosa, P. canescens and P. cerasus*. After more than 20 years of evaluation in many experiments with numerous GiSelA clones, the most promising among them seems to be 'GiSelA 3', 'GiSelA 5' and 'GiSelA 6' (Azarenko and McCluskey, 1998; Franken-Bembenek, 1998 and 2004).

The P-HL series

These are rootstocks that originated at Holovousy in the Czech Republic in 1963 and likely are hybrids of *P. avium* and *P. cerasus*. After a preliminary selection, six P-HL clones were chosen for detailed evaluation. Outside the Czech Republic, P-HL rootstocks have been tested in Poland since 1988. The results of those experiments show that the best in polish growing conditions is clone 'P-HL A'. In comparison to 'F 12/1', the 'P-HL A' rootstock improves tree productivity and enables planting of intensive sweet cherry orchards (Grzyb *et al.*, 1998; Sitarek *et al.*, 1999).

The Weiroot selections

Collection of *P. cerasus* clones began in 1960, and selection took place in 1965 at the Institute for Fruitgrowing in Weihenstephan, Munich, Germany. The 18 clones that had been selected had different vigour. Clones 10, 11 and 13 showed good characteristics in orchard trials. However, the latest experiments have revealed big incompatibility problems with the first Weiroot rootstocks. Therefore, a new series was raised from seeds of 'Weiroot 11', and the new clones, numbered 53, 72 and 158, seem to be much better than the previous ones (Stehr, 1998).

The M x M rootstocks

The M x M series originated in Oregon, USA, from a cross between *P. avium* and *P. mahaleb*. The most known in the M x M series are clones number 2, 14, 39, 60 and 97. Of these, only 'M x M 14' and 'M x M 97' are semi-dwarfing (Azarenko and McCluskey, 1998).

The Gembloux rootstocks

At a research station in Gembloux, Belgium, three rootstocks - 'Inmil' (GM 9), 'Damil' (GM 61) and 'Camil' (GM 79), were selected. 'Inmil' (*P. incisa* x *P. serulata*) is considered too weak for commercial use. 'Damil' (*P. dawyckensis*) and 'Camil' (*P. canescens*) are promising, but incompatibility may be a problem in practice (Wertheim *et al.*, 1998). In recent years new breeding programmes relevant to the dwarfism of sweet cherry trees have been initiated among the progeny of 'Damil' (Druart, 1998).

Graft incompatibility facts

Many authors (Chang, 1937; Tietierjew, 1964; Webster and Schmidt, 1996) are of the opinion that the rootstock determines the success of budding. Some of the fruit tree rootstocks produce a very good junction with top varieties, but with some others the effectiveness of budding is very low. Usually, there are no problems with the growth or cropping of sweet cherry trees on the Mazzard rootstock. In that case, "compatibility" between the two partners is good. However, this may be different when the rootstock is a hybrid of the *Prunus* species or a selection of other than *P. avium* *Prunus* species. So, we can expect incompatibility problems not only in the case of hybrid rootstocks of a different genetic origin. For example, the combination of sweet cherry cultivars with *P. cerasus* rootstocks (Weiroot series) is not always safe either (Wertheim, 1998). It means that *P. avium* and *P. cerasus* differ very much, both in visible characteristics and in metabolism. The symptoms of incompatibility vary. Incompatibility may manifest itself already in the nursery as a low percentage of buds and grafts taken, weak growth of maidens, maidens breaking in the graft zone during strong winds or yellowish leaves. In many cases, it is a result of a poor junction between scion and rootstock. Three forms of discontinuity of wood and bark are observed, namely: bark continuous, but wood discontinuous; bark discontinuous, but wood continuous; both bark and wood discontinuous (Chang, 1937). Such obvious symptoms of incompatibility were demonstrated in ‘Hedelfingen’ trees on ‘P-HL A’ in an experiment conducted in Poland by Sitarek and Grzyb (1998). One-year-old trees of ‘Hedelfingen’ on ‘P-HL A’ reached only 52.2% of the height of the trees on Mazzard seedlings, but some other cultivars budded on this rootstock were only 3.5 to 20.0% smaller. ‘Hedelfingen’ maidens on ‘P-HL A’ showed typical symptoms of incompatibility, expressed in total growth inhibition in the middle of the growing season and precocious leaf yellowing and abscission. Those trees produced apical buds as early as July and tree growth was arrested. During the first year in the orchard, the mortality rate of the trees was extremely high. In spite of clear symptoms of incompatibility, the bud-take rate of ‘Hedelfingen’ on ‘P-HL A’ was similar to other combinations. Microscopic examination of the graft union of ‘Hedelfingen’ sweet cherry trees with the ‘P-HL A’ rootstock revealed a weak junction between the two components. An isolating layer that makes proper diffusion of water and nourishing elements difficult was clearly visible. Both bark and wood were discontinuous.

In the second experiment, ‘Summit’, ‘Techlovan’, Sylvia’, ‘Regina’, ‘Lapins’ and ‘Heidegger’ were chip-budded with the dwarfing rootstocks ‘P-HL A’, ‘P-HL B’ and ‘GiSelA 5’. The same cultivars budded on ‘F 12/1’ were used as the control. The effectiveness of budding varied from 74 to 97% depending on the rootstock/cultivar combinations. However, the rootstocks had no significant influence on the number of the budded trees produced. All the cultivars tested on ‘F 12/1’ grew significantly more vigorously than those grafted on ‘P-HL A’, ‘P-HL B’ and ‘GiSelA 5’ rootstocks. One-year-old trees of ‘Heidegger’ on the dwarfing rootstocks ‘P-HL A’, ‘P-HL B’ and ‘GiSelA 5’ reached only 45 to 59% of the height of the control trees, but other cultivars included in the experiment and grafted on the same rootstocks were only 9 to 28% smaller than the control. In terms of trunk diameter a similar tendency was observed. Only on ‘F 12/1’ ‘Heidegger’ grow normally, and on ‘P-HL A’, ‘P-HL B’ and ‘GiSelA 5’ rootstocks it showed typical symptoms of incompatibility, expressed in total growth inhibition in the middle of the growing season and precocious leaf yellowing and abscission. During the first year in the orchard the mortality rate of those trees was extremely high. However, in contrast to the previous trial, microscopic examination of the graft union between ‘Heidegger’ and the dwarfing rootstocks did not show any clear isolating layer between xylem and phloem tissues of the scions and rootstocks. All the sweet cherry trees budded on ‘P-HL A’, ‘P-HL B’ and ‘GiSelA 5’ were smaller than those on ‘F 12/1’. This weak growth does not mean a lack of compatibility between the joined components; the only exception was the cultivar ‘Heidegger’. The small size of a grafted tree is an indication of the dwarfing effect of the rootstock, but it does not reveal anything about physiological incompatibility (Sitarek and Grzyb, 2005). Examples of incompatible rootstock/scion combinations citied in the literature are listed in Table 1.

Table 1. Examples of incompatible scion/rootstock combinations

Cultivar	Rootstock
‘Sam’	‘Colt’, ‘Weiroot 158’
‘Hedelfińska’	‘Colt’, ‘Weiroot 13’, ‘P-HL A’, ‘Damil’, ‘P-HL C’*
‘Burlat’	‘Colt’*, ‘MxM 97’,
‘Ambrune’	‘Colt’
‘Van’	‘Colt’
‘Bianka’	‘Damil’
‘Techlovicka’	’P-HL A’, ‘P-HL C’
‘Heidegger’	‘P-HL A’, ‘P-HL B’, ‘GiSelA 5’
‘Kordia’	‘P-HL C’
‘Karesova’	‘P-HL C’
‘Napoleona’	‘P-HL C’
‘Büttner’s Red’	‘GiSelA 5’*
’Summit’	‘Camil’, ‘Colt’*
’Stella’	‘Inmil’
’Schneiders’	‘Inmil’

Explanation: *Incompatibility may be caused by virus infection.

The early symptoms of incompatibility are a serious handicap to the nurseryman. However, from the point of view of the commercial fruit grower, it is a disadvantage when big trees, on reaching bearing age, suddenly break off at the union. This is a delayed incompatibility. In that case, trees live longer, looking normal in the beginning and even for up to 8 or 10 years, but after that they show many signs of poor health, such as small or yellowish leaves, stunted growth, premature autumn discolouration and drop of leaves, abundant flower buds formation and suckering. Sometimes, trees with incompatibility symptoms are similar to trees grown in stressful conditions such as too wet or too dry soil. For successful dwarfing rootstocks, it is perhaps necessary to have a sort of 'partial incompatibility', which allows adequate growth control, but also ensures good health and a long life span of the tree (Webster and Schmidt, 1996). 'Burlat' and 'Hedelfingen' cultivars grafted on 'Colt' are good examples of delayed incompatibility in sweet cherry cultivation. In these cases, incompatibility symptoms were not so evident, but little by little the trees declined. In the sixth year after planting in the orchard, there were only 3 out of the 12 'Burlat' trees planted and no 'Hedelfingen' trees left (Grzyb *et al.*, 1998). Problems with early tree losses affecting the variety 'Hedelfingen' have also been experienced with the rootstocks 'Damil' and 'GiSelA 10' in Germany (Stehr, 1998).

Hypotheses that try to explain the lack of or reduced compatibility

Since the end of the nineteenth century many attempts have been made to explain the problems of incompatibility. Early investigations attributed incompatibility chiefly to structural weakness and abnormal deposits at the union, and the differences in the anatomy of the rootstock and scion as well as the difference in the power of the protoplasmic reaction between the rootstock and scion, resulting in a higher or lower concentration of the cell sap. Older conceptions regarded the botanical relationship as a fair guide to the compatibility of the rootstock and scion. It meant that plants belonging to the same botanical group might be successfully grafted. Later reports have revealed that the cause is of a biochemical origin. Reduced compatibility of heterogenetic grafts in sweet cherry trees is reflected by the varying amounts of polyphenols and sometimes by an accumulation of phenolic compounds above the union (Usenik and Stampar, 2001). The rootstocks 'F 12/1', 'GiSelA 4', 'GiSelA 5', 'GiSelA 12', 'PiKu 4', 'Edabriz', 'Weiroot 13', 'Weiroot 72', 'Weiroot 158' were found to cause different concentrations of polyphenols in the phloem of 'Lapins' sweet cherry trees. Homogenetic grafts often show similar levels of polyphenols along the union (Gebhardt and Feucht, 1982). Therefore, rootstock clones of various cherry species can influence symptoms of incompatibility faster than *P. avium*.

Research work in the USA (Lang *et al.*, 1997) has shown that scions on several of the GiSelA rootstocks are very sensitive to infections with plum dwarf virus (PDV) and/or prune necrotic ringspot virus (PNRSV). This was particularly evident with 'Gisela 1' and 'GiSelA 10', but was also recorded with 'GiSelA 7' and 'GiSelA 8'. In these tests 'GiSelA 5' and 'GiSelA 6', which are currently two of the most promising in the GiSelA series, fortunately show tolerance to infection by the two viruses. However, in a Polish trial, 'Bűttner's Red' sweet cherry trees grafted on 'GiSelA 5' did not grow well after PDV infection. A high number of declining flower buds was observed and a greater reduction in growth from one year to the next resulting in a slow decline of all the trees.

Table 2. Examples of good compatibility between sweet cherry cultivars and two dwarfing rootstocks the basis of the results of Polish trials

Rootstock	Cultivar
'P-HL A'	'Rivan', 'Burlat', 'Merton Premier', 'Karesova', Büttner's Red', 'Kordia', 'Vanda', 'Techlovan', 'Regina', 'Summit', 'Lapins', 'Sylvia'
Gisela 5	'Burlat', 'Vega', 'New York 980.1', 'Kordia', 'Regina', 'Techlovan', 'Summit', 'Lapins', 'Sylvia', 'Karina'

Conclusions

The causes of incompatibility show that it is necessary to test as many cultivars on promising new rootstocks as possible to prevent surprises. As new rootstocks and cultivars are regularly being introduced, such testing requires constant attention. The introduction of dwarfing rootstocks to practice should be preceded by detailed investigations of the compatibility between the two graft components. Otherwise, neither the nurseryman nor the fruit grower will be satisfied.

Incompatibility between the rootstock and scion may be influenced by many factors. Early screening of new sweet cherry rootstocks for compatibility with the main cultivars recommended for cultivation is an important step in characterizing rootstock suitability for commercial production.
On the basis of the results of Polish trials, a list of cultivars compatible with two dwarfing rootstocks used in practice has been prepared (Table 2). The growers who will set up intensive sweet cherry orchards with such trees can be assured of success.

References

1. Azarenko A.N. and McCluskey R. (1998). Performance of 'Napoleon' trees topworked on Selected Giessen, M x M, GM, Colt, and Mazzard rootstocks. Acta Hort., 468, 321-326.
2. Balmer M., 1998. Preliminary results on planting densities and rain covering for sweet cherry on dwarfing rootstock. Acta Hort., 468, 433-439.
3. Chang W.T. (1937) Studies in incompatibility between stock and scion, with special reference to certain deciduous fruit trees. J. Pom. Hort. Sci., 15, 267-325.
4. Druart Ph. (1998) Advancement in the selection of new dwarfing rootstocks into the progeny of Damil (GM 61/1).
5. Facteau T.J., Chestnut N.E. and Rowe K.E. (1996) Tree, fruit size and yield of 'Bing' sweet cherry as influenced by rootstock, replant area and training system. Scienta Hort., 67, 13-26.
6. Franken-Bembenek S. (1998) Gisela 5 (148/2) – dwarfing rootstock for sweet cherries. Acta Hort., 468, 279-283.
7. Franken-Bembenek S. (2004) GiSelA 3 (209/1) – a new cherry rootstock clone of the Giessen series. Acta Hort., 658, 141-143.
8. Gebhardt K. and Feucht W. (1982) Polyphenol changes at the union of *Prunus avium/Prunus cerasus* grafts. J. of Hort. Sci., 57, 253-258.
9. Grzyb Z.S., Sitarek M. And Omiecińska B. (1998) Growth and fruiting of five sweet cherry cultivars on dwarfing and vigorous rootstocks. Acta Hort., 468, 333-338.
10. Lang G., Howell W. and Mink G. (1997) Virus tolerance and sensitivity of cherry rootstocks. Good Fruit Grower, May 15, 22-26.
11. Meland M. and Skjervheim K. (1998) Rain cover protection against cracking for sweet cherry orchards. Acta Hort., 468, 441-447.
12. Sitarek M. and Grzyb Z.S. (1998) Bud-take and growth of sweet cherry trees budded on different rootstocks. Journal of Fruit and Ornamental Plant Research, 1, 23-31.
13. Sitarek M. and Grzyb Z.S. (2005) Nursery results of bud-take and growth of six sweet cherry cultivars budded on four clonal rootstocks. Acta Hort. (in press).
14. Sitarek M., Grzyb Z.S., Czynczyk A. annd Omiecińska B. (1999) Growth and fruiting of sweet cherry trees grafted on various rootstocks or treated with Cultar. J. of Fruit and Ornamental Plant Research, 1, 11-17.
15. Stehr R. (1998) First results with dwarfing rootstocks in northern Germany as part of a National German Rootstock Trial. Acta Hort., 468, 297-306.
16. Tietierjew F.K. (1964) Czieriesznja I biologiczeskije osnowy jejo osiewierjenija. Izdatjelstwo "Nauka", Moskwa.
17. Usenik V. and Stampar F. (2001) Different rootstocks for cherries – influence on polyphenol content and graft incompatibility. Acta Hort., 557, 175-179.
18. Webster A.D. (1996) Cherry rootstock evaluation at East Malling. Acta Hort., 410, 247-255.
19. Webster A.D. (1998) The taxonomic classification of sweet and sour cherries and brief history of their cultivation. In: Cherries: crop physiology, production and uses. Cambridge, CAB International, 3-25.
20. Webster A.D. (2004) Vigour mechanisms in dwarfing rootstocks for temperate fruit trees. Acta Hort., 658, 29-41.
21. Webster A.D. and Schmidt H. (1996) Rootstocks for sweet and sour cherries. In: Cherries: Crop physiology, production and uses. Cambridge (UK), CAB International, 127-167.

22. Wertheim S.J. (1998) Rootstock guide: apple, pear, cherry, European plum. Fruit Research Station Wilhelminadorp, the Netherlands.
23. Wertheim S.J., Balkhoven J.M.T., Callesen O., Claverie J., Vercammen J., Ystaas J. and Vestrheim S. (1998)R esults of two international cherry rootstock trials. Acta Hort., 468, 249-265.

INTERNAL QUALITY OF APPLES DURING STORAGE
ĀBOLU IEKŠĒJĀS STRUKTŪRAS KVALITĀTE GLABĀŠANAS LAIKĀ

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Kopsavilkums

Pētījumi veikti divas sezonas (2003./2004. un 2004./2005.) 29 ābolu šķirnēm no sešgadīgiem kokiem, kas potēti uz M.9. Āboli tika vākti, kad to cietes indekss bija no 6 līdz 8. Āboli glabāti 4 mēnešus +2°C temperatūrā. Ābolu mīkstuma blīvums, titrējamo skābju saturs, šķīstošā sausna tika noteikti ražu novācot, un pēc 2 un 4 mēnešiem. Pēc 4 mēnešu glabāšanas stingri āboli bija šķirnēm ‘Fuji’, ‘Fiesta’, ‘Pinova’, ‘Topaz’, ‘Alwa’, ‘Gorjaczkowski Seedling’ un ‘XIX-133-D2’. Augsts šķīstošās sausnas saturs (>15°Brix) bija šķirnēm 'Redgold' un 'Golden Delicious', bet augsts titrējamo skābju saturs (>0.6%) - 'Topaz' un 'Gorjaczkowski Seedling'. Šķīstošās sausnas un skābju attiecība palielinājās glabāšanas laikā. Pēc 4 mēnešu glabāšanas augstākā attiecība bija šķirnēm 'Fuji', 'Gala' un 'Redgold' (>60) salīdzinoši zema (<30) šķirnēm 'Gorjaczkowski Seedling', 'Sawa', 'Topaz' un 'Witos'.

Abstract

The investigations were carried out in two successive seasons (2003/2004 and 2004/2005) on 29 apple cultivars obtained from trees on the rootstock M.9, which at the beginning of the investigation were six years old. The apples were picked when their starch index reached the values from 6 to 8. Fruit samples were stored for 4 months in a common cold storage at +2°C. At harvest and after 2, and 4 months of storage, firmness, titratable acidity and soluble solids were determined. Apples of the evaluated cultivars significantly differed in firmness and organic components content, shaping their internal quality. After 4 months of storage high firmness, independently of the season of determination, was characteristic for ‘Fuji’, ‘Fiesta’, ‘Pinova’, ‘Topaz’, ‘Alwa’, ‘Gorjaczkowski Seedling’ and ‘XIX-133-D2’ apples. A high soluble solids content (>15°Brix) was recorded in 'Redgold' and 'Golden Delicious' and a high titratable acidity (>0.6%) in 'Topaz' and 'Gorjaczkowski Seedling' apples. The ratio of soluble solids to organic acids increased with storage time. After 4-month of storage a very high value of that ratio was found in 'Fuji', 'Gala' and 'Redgold' (>60) and comparatively low (<30) in 'Gorjaczkowski Seedling', 'Sawa', 'Topaz' and 'Witos'.

Key words: apples, firmness, soluble solids content, titratable acidity

Introduction

According to currently binding standards fruits are evaluated on the basis of their external appearance, however, new standards include requirements concerning their internal quality traits. Apart from firmness, an important role is played by the soluble solids content and acidity, i.e. parameters affecting the fruit taste. The results of the investigations show that the internal qualitative traits of apples depend significantly on the cultivar (Szklarz and Pacholak, 2000; Skrzyński *et al.*, 2004) and on the time of storage (Błaszczyk, 1998). Konopacka and Płocharski (2002) point to the importance of the flesh firmness. They also report that the firmness of apples after storage is closely correlated with their firmness at the time of harvest. An important role is also played by organic acids which are substrates in fruit energetic reactions which is connected with systematic the decrease of acidity in stored apples (Ben, 1996).

The work aimed at comparing the firmness, the soluble solids content and the acidity of various apple cultivars during storage. The results of this evaluation may be useful for, among others, choosing progenous forms in breeding work.

Materials and Methods

The experiment was performed in two storage seasons (2003/2004 and 2004/2005). The investigations included 29 apple cultivars. In the first season the apple trees on the rootstock M.9 were six years old. They belonged to the cultivar collection of the Department of Pomology and Basic

Natural Sciences in Horticulture in Warsaw-Wilanów. The harvest time was set on the basis of starch test. Apples were picked when their starch index reached the values from 6 to 8. Fruit samples (about 50 apples of each cultivar per sample) were stored in a common cold storage at +2º C and relative air humidity of about 95%. The experiment was set in three replications. At harvest and after 2, and 4 months of storage, the firmness, titratable acidity and soluble solids were determined. Firmness was measured using an Instron penetrometer (type 5542) using standard piercing mandrel with the diameter of 11.3 mm. Soluble solids content was determined using Abbe refractometer. Juice acidity was determined by titration with 0.1 M solution of sodium hydroxide up to pH 8.1. Results were converted into the malic acid content. The data was used to calculate quantitative proportions between the soluble solids content and acidity. Results were analyzed statistically using one-factor variance analysis. Newman-Keuls test was used to evaluate the significance of differences between means at the significance level of $\alpha = 0.05$.

Results and Discussion

Apples of the evaluated cultivars showed significant variation in respect to all the examined traits.

Table 1. Apple firmness as influenced by cultivar and storage period

Cultivar	Firmness (N)					
	2003/2004			2004/2005		
	at harvest	after 2 months	after 4 months	at harvest	after 2 months	after 4 months
Alwa	82.8 gh*	70.0 ij	64.6 ij	79.7 efg	48.7 fg	45.0 de
Arlet	84.3 ghi	67.0 ij	49.9 g	76.0 defg	61.3 ijk	50.5 ef
Cortland	60.1 bcde	46.6 bcde	39.6 cde	65.2 abcd	40.3 cd	34.7 bc
Elstar	65.7 bcde	48.5 cdef	39.0 cde	63.9 abc	43.0 de	36.1 bc
Fiesta	83.3 gh	80.0 k	64.9 ij	69.2 bcde	60.2 ij	57.3 g
Freedom	63.6 bcde	50.8 def	38.7 cde	65.5 abcd	30.2 a	27.2 a
Fuji	78.0 fg	72.5 j	64.4 ij	82.5 fg	69.2 m	64.1 h
Gala	89.5 hi	68.3 ij	63.8 ij	86.7 g	60.5 ij	51.2 ef
Gloster	87.3 ghi	68.2 ij	61.3 hi	96.5 h	51.9 gh	45.7 de
Golden Delicious	69.0 def	50.5 def	40.3 cde	71.8 cdef	45.8 ef	46.5 de
Gorjaczkowski Seedling	98.0 j	90.6 l	64.5 ij	102.5 h	63.3 jk	53.9 fg
Jonamac	49.6 a	43.8 bcd	43.6 defg	54.8 a	37.1 bc	-
Laxton's Superb	69.0 def	52.2 def	46.7 efg	55.1 a	49.8 fgh	48.7 def
Ligol	58.5 abcd	56.0 fg	48.7 fg	58.2 ab	53.5 h	46.1 de
Melodie	54.1 ab	49.6 cdef	37.5 cd	58.2 ab	33.2 ab	-
Melrose	66.0 bcde	49.3 cdef	33.9 bc	76.7 efg	45.9 ef	42.5 d
Mutsu	82.6 gh	63.4 hi	46.2 efg	79.9 efg	49.0 fg	47.3 de
Odra	69.6 def	55.4 efg	41.6 cdef	77.9 efg	39.8 cd	35.9 bc
Pinova	66.8 cde	67.7 ij	56.8 h	86.3 g	64.8 kl	58.4 g
Rajka	65.0 bcde	47.1 bcdef	39.3 cde	55.5 a	32.7 ab	29.8 ab
Redgold	93.5 ij	75.3 jk	56.2 h	86.3 g	48.6 fg	48.6 def
Rubin	64.1 bcde	60.1 gh	46.8 efg	62.3 abc	39.7 cd	34.4 bc
Rubinette	61.6 bcde	40.0 b	34.6 bc	58.7 ab	35.6 bc	35.3 bc
Sawa	58.9 abcd	40.2 b	23.5 a	79.9 efg	32.9 ab	27.8 a
Selena	60.7 bcde	55.0 efg	34.4 bc	62.3 abc	37.5 bc	35.2 bc
Spartan	71.6 ef	71.2 ij	58.6 hi	71.2 cde	50.3 fgh	37.7 c
Topaz	82.3 gh	81.7 k	70.6 j	71.8 cdef	58.0 i	50.5 ef
Witos	55.2 abc	32.4 a	29.6 b	55.9 a	32.7 ab	30.3 ab
XIX-133-D2	65.5 bcde	69.0 ij	64.4 ij	69.6 cde	67.5 lm	57.9 g

*Mean separation, within the columns, by Newman Keuls test, at α=0.05

One of the most important quality factors, from the point of view of the consumer, is the flesh firmness. Out of all the evaluated cultivars a high firmness at harvest was characteristic for ‘Gorjaczkowski Seedling’ (98.0 and 102.5 N, respectively in the successive seasons), ‘Redgold’ (93.5 and 86.3 N), ’Gala’ (89.5 and 86.7 N) and ‘Gloster’ (87.3 and 96.5 N) apples. Additionally high firmness after harvest in the second year of the investigation was observed in the ‘Pinova’ cultivar (86.3 N). Fruit harvested in 2004 became soft quicker during storage than the fruits harvested in the previous year. After 4 months of storage in the season 2003/2004 the significantly highest firmness was characteristic for ‘Topaz’ apples (70.6 N). At the same time high firmness was also observed in the fruit of ‘Fiesta’ (64.9 N) and ‘Alwa’ (64.6 N) cultivars. In the season 2004/2005 after 4 months of storage the most firm were ‘Fuji’, ‘Pinova’, ‘XIX-133-D2’ and ‘Fiesta’ apples. Regardless of the season of determination, the least firm apples at harvest were ‘Jonamac’ apples while ‘Witos’ and ‘Sawa’ apples became soft most quickly during storage and after 4 months were clearly less firm than apples of the remaining cultivars (Table 1).

Generally, apples picked in the season 2004 were characterized by a lower content of soluble solids and lower acidity as compared to those obtained in the year 2003. Lower soluble solids content and acidity most probably resulted from a cool summer in 2004.

Table 2. Apple soluble solids content as influenced by cultivar and storage period

Cultivar	Soluble solids content (°Brix)					
	2003/2004			2004/2005		
	at harvest	after 2 months	after 4 months	at harvest	after 2 months	after 4 months
Alwa	14.5 cdef*	14.6 cdefghi	14.4 cdef	12.4 abcd	12.7 bcd	12.9 bcde
Arlet	14.7 def	15.7 ijk	15.0 def	13.1 abcdef	13.1 bcdef	13.5 cdefg
Cortland	14.3 bcdef	14.9 defghij	14.2 bcdef	13.3 abcdef	13.4 cdefg	13.0 bcde
Elstar	14.6 cdef	15.3 ghij	15.6 f	13.5 bcdef	13.8 cdefgh	15.1 ij
Fiesta	14.0 abcde	15.5 hij	14.8 def	12.8 abcdef	13.1 bcdef	12.6 abc
Freedom	13.1 ab	13.3 ab	14.3 cdef	12.5 abcde	13.5 cdefg	12.3 ab
Fuji	15.8 ghi	15.9 jk	14.8 def	13.9 efg	14.3 fgh	12.9 bcde
Gala	14.9 efg	14.9 defghij	14.9 def	12.0 a	13.3 cdefg	12.7 abcd
Gloster	15.0 efg	15.1 fghij	14.8 def	12.6 abcde	14.3 fgh	13.9 efgh
Golden Delicious	16.0 hi	16.6 k	15.7 f	15.3 h	14.5 gh	14.8 hij
Gorjaczkowski Seedling	15.3 fgh	14.6 cdefghi	14.2 bcdef	13.7 def	14.3 fgh	13.8 defg
Jonamac	13.8 abcde	13.7 abc	14.8 def	13.6 cdef	13.0 bcde	-
Laxton's Superb	16.6 i	16.7 k	14.9 def	17.4 i	16.8 j	17.0 k
Ligol	14.3 bcdef	13.7 abc	13.8 abcde	13.4 abcdef	12.6 bc	12.7 abcd
Melodie	14.0 abcde	13.5 abc	12.8 ab	12.8 abcdef	13.6 cdefg	-
Melrose	12.7 a	13.1 a	13.0 abc	12.9 abcdef	13.7 cdefg	13.1 bcdef
Mutsu	14.5 cdef	15.0 defghij	13.7 abcd	12.9 abcdef	14.0 defgh	14.0 fgh
Odra	13.6 abcd	13.6 abc	13.1 abc	13.6 cdef	13.6 cdefg	14.3 ghi
Pinova	13.8 abcde	14.4 bcdefgh	13.6 abcd	14.9 gh	14.9 h	15.5 j
Rajka	14.7 def	15.3 ghij	15.3 ef	13.0 abcdef	13.2 cdef	11.9 a
Redgold	16.1 hi	16.5 k	16.8 g	15.7 h	16.0 i	15.3 j
Rubin	14.6 cdef	15.2 fghij	14.9 def	12.7 abcde	13.1 bcdef	13.7 defg
Rubinette	16.5 i	16.6 k	14.8 def	14.9 gh	14.1 efgh	14.4 ghi
Sawa	12.8 a	15.1 efghij	13.4 abcd	12.1 ab	12.0 ab	13.0 bcde
Selena	13.0 a	13.9 abcde	12.9 abc	12.2 abc	11.7 a	12.4 ab
Spartan	13.4 abc	14.7 cdefghij	14.6 def	12.4 abcd	14.1 efgh	13.7 defg
Topaz	14.6 cdef	14.7 cdefghij	14.6 def	13.1 abcdef	13.6 cdefg	13.7 defg
Witos	13.2 ab	13.8 abcd	12.7 a	12.2 abc	12.7 bcd	13.1 bcdef
XIX-133-D2	13.9 abcde	14.1 abcdefg	13.5 abcd	14.1 fg	12.9 bcde	16.8 k

* Mean separation, within the columns, by Newman Keuls test, at α=0.05

A high soluble solids content directly after harvest (>16º Brix in the year 2003 and >15º Brix in 2004) was characteristic for ‘Laxton’s Superb’, ‘Redgold’ and ‘Golden Delicious’ apples (Table 2).

In the case of most apple cultivars, after two months of storage an increase of the soluble solids content was noted while after successive two months the value of this indicator decreased. In the season 2003/2004 after 4 months of storage the highest value of the soluble solids content was observed in ‘Redgold’ apples. In that season, a high content was also characteristic for ‘Golden Delicious’ and ‘Elstar’ fruits. On the other hand, low soluble solids content was noted, independently of the time of determination, in ‘Melrose’, ‘Sawa’ and ‘Selena’ apples (usually from 12 to 13º Brix). In the season 2004/2005 high soluble solids content after 4 months of storage was noted in ‘Laxton’s Superb’, ‘XIX-133-D2’, ‘Pinova’ and ‘Redgold’ apples.

The effect of cultivar on the apple titratable acidity was proved at all times of analyses (Table 3).

Table 3. Apple titratable acidity as influenced by cultivar and storage period

Cultivar	Titratable acidity (% malic acid)					
	2003/2004			2004/2005		
	at harvest	after 2 months	after 4 months	at harvest	after 2 months	after 4 months
Alwa	0.90 lm*	0.67 hi	0.52 kl	0.44 abcd	0.39 bcdefgh	0.34 ef
Arlet	0.71 gij	0.76 ij	0.41 defghijk	0.48 abcde	0.45 efgh	0.35 ef
Cortland	0.63 cdefgi	0.53 defg	0.34 defghi	0.60 efgh	0.45 efgh	0.43 ghi
Elstar	0.67 efgij	0.63 gh	0.41 efghijk	0.63 fgh	0.70 ij	0.54 j
Fiesta	0.80 jkl	0.86 j	0.55 lm	0.48 bcde	0.36 abcdefg	0.34 ef
Freedom	0.64 defgij	0.53 defg	0.42 ghijkl	0.52 cdef	0.38 bcdefgh	0.27 bcde
Fuji	0.61 cdefgi	0.30 ab	0.15 a	0.32 a	0.23 a	0.20 ab
Gala	0.34 a	0.27 a	0.19 ab	0.32 a	0.28 abc	0.20 ab
Gloster	0.52 bcdef	0.54 efg	0.46 hijkl	0.44 abcd	0.35 abcdef	0.37 efg
Golden Delicious	0.66 efgij	0.49 cdef	0.38 defghij	0.69 ghi	0.40 bcdefgh	0.32 def
Gorjaczkowski Seedling	1.17 n	0.79 ij	0.63 mn	0.87 k	0.76 j	0.64 k
Jonamac	0.40 ab	0.26 a	0.21 abc	0.47 abcde	0.33 abcde	-
Laxton's Superb	0.73 gijk	0.61 fgh	0.36 defghi	0.56 defg	0.42 cdefgh	0.24 abcd
Ligol	0.54 bcdef	0.35 abc	0.31 cdefgh	0.43 abcd	0.30 abcd	0.27 bcde
Melodie	0.87 klm	0.64 gh	0.43 ghijkl	0.80 ijk	0.50 gh	-
Melrose	0.47 bc	0.43 bcde	0.42 fghijk	0.39 abc	0.36 abcdefg	0.33 ef
Mutsu	0.78 ijkl	0.47 cdef	0.33 cdefghi	0.46 abcde	0.33 abcde	0.32 def
Odra	0.64 defgij	0.48 cdef	0.43 ghijkl	0.78 ijk	0.62 i	0.45 hi
Pinova	0.52 bcdef	0.39 abcd	0.27 bcd	0.63 fgh	0.43 defgh	0.34 ef
Rajka	0.59 cdefg	0.52 defg	0.39 defghijk	0.42 abcd	0.33 abcde	0.22 abc
Redgold	0.51 bcde	0.32 ab	0.28 bcdef	0.33 ab	0.26 ab	0.18 a
Rubin	0.62 cdefgi	0.48 cdef	0.38 defghij	0.44 abcd	0.34 abcde	0.29 cde
Rubinette	0.94 m	0.68 hi	0.46 ijkl	0.63 fgh	0.48 fgh	0.40 fgh
Sawa	0.60 cdefg	0.68 hi	0.52 jkl	0.83 jk	0.51 h	0.49 ij
Selena	0.69 fgij	0.51 defg	0.37 defghi	0.51 cdef	0.42 defgh	0.32 def
Spartan	0.53 bcdef	0.41 bcde	0.27 bcde	0.42 abcd	0.35 abcdef	0.28 bcde
Topaz	0.99 m	0.83 j	0.65 n	0.80 ijk	0.63 i	0.49 ij
Witos	0.77 ijkl	0.69 hi	0.45 hijkl	0.71 hij	0.63 i	0.43 ghi
XIX-133-D2	0.48 bcd	0.36 abc	0.29 bcdefg	0.47 abcde	0.42 cdefgh	0.33 ef

* Mean separation, within the columns, by Newman Keuls test, at $\alpha=0.05$

Both in the year 2003 and 2004 directly after harvest it was noted that ‘Gorjaczkowski Seedling’ apples were characterized by a significantly highest acidity which converted into the content of malic acid in the successive years amounted to 1.17% and 0.87%, respectively. Also ‘Topaz’ apples were characterized by high acidity independently of the year of investigations. On the other hand, ‘Gala’ apples showed the lowest acidity (0.34% and 0.32%, respectively in the successive years of investigations). After 2 and 4 months of storage statistically the highest acidity was observed in ‘Topaz’ and ‘Gorjaczkowski Seedling’ apples and the lowest in ‘Fuji’ and ‘Gala’. The rate of acidity decrease during storage depended to a high degree on the cultivar. The greatest decrease of that index in the season 2003/2004 was observed in ‘Fuji’ cultivar while in the successive season in ‘Laxton’s Superb’. On the other hand, in the case of ‘Melrose’ apples the decrease of acidity was slight amounting to about 10% in both seasons.

The proportion of the soluble solids content to acidity affects the taste of fruits. Apples in which the value of this proportion is too high may be evaluated by consumers as too sweet, while if the proportion of sugars to acids is too low, the fruits are sour. ‘Redgold’, ‘Fuji’ and ‘Gala’ apples were always characterized by a high quantitative proportion of soluble solids content to acidity which mostly resulted of their low acidity. The lowest value of this proportion was noted in ‘Gorjaczkowski Seedling’ apples (Table 4).

Table 4. Proportion of the soluble solids content to acidity as influenced by cultivar and storage period

Cultivar	2003/2004			2004/2005		
	at harvest	after 2 months	after 4 months	at harvest	after 2 months	after 4 months
Alwa	16.4 abcd*	22.0 abc	27.8 ab	28.3 defgh	32.3 abcd	37.7 cdef
Arlet	21.0 bcdefg	20.7 ab	37.0 abcde	27.7 defgh	29.2 abcd	39.5 def
Cortland	22.7 cdefgh	28.5 cdefg	41.5 bcdef	22.1 bcde	30.3 abcd	30.3 abcd
Elstar	22.1 cdefg	24.3 abcde	38.3 abcde	21.8 bcd	20.3 a	28.1 abc
Fiesta	17.6 abcde	18.2 a	26.9 ab	26.7 defgh	36.0 cde	38.6 def
Freedom	20.6 bcdefg	25.0 abcdef	34.3 abcd	24.2 cdefg	36.4 cde	45.3 efg
Fuji	25.8 gh	53.0 k	99.4 i	43.0 j	65.0 f	64.2 h
Gala	44.6 k	55.9 k	80.3 h	38.5 i	48.1 e	64.1 h
Gloster	29.0 hi	27.8 bcdefg	32.0 abcd	29.3 defgh	41.5 de	38.1 def
Golden Delicious	24.2 fgh	34.9 ghij	41.3 bcdef	22.5 bcdef	36.6 cde	46.6 efg
Gorjaczkowski Seedling	13.1 a	18.5 a	23.0 a	15.7 ab	18.9 a	21.7 a
Jonamac	35.9 j	52.3 k	69.4 g	28.8 defgh	39.4 de	-
Laxton's Superb	22.9 defgh	27.5 bcdefg	41.8 bcdef	31.5 gh	40.7 de	72.6 i
Ligol	26.7 ghi	39.2 j	44.4 cdef	31.2 gh	42.2 de	46.7 efg
Melodie	16.1 abc	21.3 abc	29.9 abcd	16.2 ab	27.5 abcd	-
Melrose	27.3 ghi	30.4 defgh	31.4 abcd	33.6 h	38.1 de	40.8 def
Mutsu	18.9 abcdef	32.3 fghi	41.8 bcdef	28.1 defgh	42.0 de	44.1 efg
Odra	21.4 cdefg	28.7 cdefg	30.7 abcd	17.5 abc	21.8 ab	32.3 bcd
Pinova	26.8 ghi	37.2 ij	51.5 ef	23.7 cdefg	34.3 bcde	46.2 efg
Rajka	25.0 fgh	29.2 cdefg	39.3 bcdef	30.6 gh	40.7 de	54.1 g
Redgold	31.8 i	52.2 k	66.5 g	48.2 k	62.6 f	85.6 j
Rubin	23.8 efgh	32.0 efghi	38.8 abcde	28.6 defgh	41.2 de	46.6 efg
Rubinette	17.5 abcde	24.4 abcde	32.6 abcd	23.7 cdefg	29.2 abcd	36.6 cde
Sawa	21.5 cdefg	22.7 abcd	26.6 ab	14.5 a	23.5 abc	26.6 ab
Selena	19.1 abcdef	27.4 bcdefg	35.3 abcd	23.8 cdefg	27.7 abcd	39.0 def
Spartan	25.6 fgh	36.0 hij	53.6 f	29.5 efgh	41.1 de	48.7 fg
Topaz	14.7 ab	17.8 a	22.6 a	16.5 ab	21.4 ab	28.0 abc
Witos	17.2 abcde	20.1 ab	28.4 abc	17.5 abc	20.2 a	30.3 abcd
XIX-133-D2	29.0 hi	39.2 j	46.1 def	29.9 fgh	30.9 abcd	51.4 g

* Mean separation, within the columns, by Newman Keuls test, at $\alpha=0.05$

Conclusions

The sinvestigated apple cultivars were characterized by a great differentiation of the flesh firmness. The highest firmness after storage in the season 2003/2004 was characteristic for 'Topaz' apples while in the season 2004/2005 significantly the most firm were 'Fuji' apples.

High soluble solids content (over 15ºBrix) were observed in 'Redgold' and 'Golden Delicious' apples while high acidity (over 0.6%) was characteristic for 'Topaz' and 'Gorjaczkowski Seedling' apples.

With storage time a mutual quantitative proportion of the soluble solids content to acidity increased. The highest values of that proportion were shown by 'Fuji' and 'Gala' apples. It may affect the length of their storage period and also determine their evaluation by consumers.

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References

1. Ben J. (1996) Wpływ warunków chłodni zwykłej i kontrolowanej atmosfery na zdolność przechowalniczą jabłek odmiany Elise. Nowe Rośliny i Technologie w Ogrodnictwie. Poznań, 117-120.
2. Błaszczyk J. (1998) Wstępne wyniki badań nad przechowywaniem jabłek odmian Rubin i Rubinette w chłodni KA. Zeszyty Naukowe AR w Krakowie, 333, 383-387.
3. Konopacka D. and Płocharski J. (2002) Effect of picking maturity, storage technology and shelf-life on changes of apple firmness of 'Elstar', 'Jonagold' and 'Gloster' cultivars. Journal of Fruit and Ornamental Plant Research, 10, 15-26.
4. Skrzyński J., Poniedziałek W. and Dziedzic W. (2004) Wstępna ocena wybranych cech jakości parchoodpornych odmian jabłek i ich przydatności do suszenia. Folia Universitatis Agriculturae Stetinensis Agricultura, 240(96), 175-178.
5. Szklarz M. and Pacholak E. (2000) Niektóre parametry jabłek odmian i klonów jabłoni parchoodpornych i mało wrażliwych na parcha po przechowaniu. Zeszyty Naukowe ISiK, 8, 345-348.

THE INFLUENCE OF MAIDEN TREE QUALITY ON GROWTH AND CROPPING OF TWO PEAR CULTIVARS IN THE ORCHARD
STĀDU KVALITĀTES IETEKME UZ DIVU BUMBIERU ŠĶIRŅU AUGUMU UN RAŽOŠANU DĀRZĀ

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Kopsavilkums

Izmēģinājums tika ierīkots Augļkopības Izmēģinājumu stacijā pie Vroclavas (Polijas dienvidrietumos) 2001.-2004. gadā. Izmēģinājumā tika pētīta viengadīgu un divgadīgu dažādas kvalitātes sazarotu stādu ietekme uz koku augumu un ražību divām bumbieru šķirnēm 'Carola' un 'Dicolor', kas potētas uz cidonijas S_1 un stādītas 2001. gada pavasarī. Koki stādīti 1.2 x 3.5 m attālumos (2381 koki ha^{-1}). Visiem kokiem veidots vārpstveida vainags pēc V-Güttingen sistēmas. Līdz ceturtajam augšanas gadam koku augums un ražība atšķīrās atkarībā no stādu kvalitātes. Viengadīgi acoti stādi deva labāko pieaugumu dārzā, bet viengadīgi potēti auga krietni vājāk, īpaši 'Carola'. Divgadīgu stādu stādīšana nedeva būtisku ražas palielinājumu. Sākotnējie pētījuma rezultāti rāda, ka viengadīgi acoti stādi dod augstākās ražas. Mazākie potētie koki deva mazāku ražu un bija ar zemāko ražas efektivitātes indeksu.

Abstract

The experiment was conducted at the Fruit Experimental Station near Wrocław (south-western part of Poland) in 2001-2004. Wrocław area belongs to the warmest regions in Poland. The influence of maiden trees quality on growth and cropping of 2 pear cvs. was estimated. The experiment was carried out on 'Carola' and 'Dicolor' trees budded on quince S_1 rootstock and planted in spring 2001 in a randomised block design in 4 replications with 6 trees per plot. Trees were spaced in rows at 1.2 m whereas the distance between rows equalled 3.5 m (2381 trees per hectare). The maiden trees varied in age from 2-year-old (the oldest) to 1-year-old grafted trees (the youngest). All pear tree canopies were formed as a spindle and were trained in a V-Güttingen system. Until the fourth year after planting, growth and yield were significantly affected by maiden trees quality. One-year-old budded trees were characterised by the strongest vigour in the orchard, while one-year-old grafted trees grew rather weak (especially with 'Carola'). Planting 2-year-old maidens didn't have positive influence on tree cropping in the orchard. Preliminary results of the study proved that 1-year-old budded trees, irrespective of cultivar, gave the highest yield. The smallest grafted trees cropped less and had the lowest crop efficiency index. Maiden trees quality of both cultivars had no clear influence on mean fruit weight.

Key words: pear, maiden trees quality, growth, cropping

Introduction

In the recent years, more and more interest in pear cultivation is observed in Poland. Until recently, it has been less profitable than apple cultivation and much more risky in terms of production. In comparison to apple trees, pear trees start bearing later and yield worse. Pear trees have higher climate-soil requirements and their fruits show worse storage ability. The number of cultivars and rootstocks suitable for pear orchards is limited, too (Mika, 1995).

Early and high productivity of pear trees first of all depends on cultivar, rootstock and maiden tree quality. According to Deckers and Schoofs (2001), for pear trees planted in high density planting systems the quality of the planting material should be high. It should be a 2-year-old tree with 6 to 8 laterals obtained by pruning back the 1-year-old trees in the fruit tree nursery. There is an important difference in productivity between a 1-year-old feathered tree and a 2-year-old feathered tree during the first year after planting. When a 1-year-old whip is planted, the productivity will be delayed by a period of 2 years during which the frame of the tree has to be developed. For intensive high density pear plantings only 2-year-old trees are recommended. Feathered 2-year –old trees for modern apple orchards are the best, because they give high and early yields (Oosten, 1978; Czynczyk, 1989;

Sadowski, 2005). Such trees cannot be pruned after planting (Mika, 2001. High quality nursery material is essential for a successful production system, with the goal of early production (Green, 1991). In Jacyna (2004) study, branching was better with dwarf Quince MA rootstock than on standard 'Bartlett' seedling rootstock, probably because maiden pear trees have a limited branching capacity in comparison with the tress of other fruit species, such as apples or sour cherries. Planting material is produced in the nursery for 2 (1-year-old trees) or for 3 years (2-year-old trees). By winter grafting the three-year-cycle of production could be shortened to two years. This method might be cheaper than traditional ones and may reduce the stress connected with older trees transplanting (Ferree, 1976). To decrease the harmful influence of transplanting on tree growth, more often (for example in Holland or Norway), maiden trees are produced in plastic containers. These trees without their root system damaged, grow much better after planting in the orchard (Czynczyk, 1989).

The aim of this study was to compare the growth, yield and fruit quality of 2 pear cultivars depending on maiden tree quality in the Lower Silesia region SW Poland.

Materials and Methods

The experiment was conducted at the Fruit Experimental Station-Samotwór near Wrocław (south-western part of Poland) in 2001-2004. The Wrocław area belongs to the warmest regions in Poland. The influence of maiden tree quality on growth and cropping of 2 pear cultivars was estimated. The experiment was carried out with 'Carola' and 'Dicolor' trees budded on quince S_1 rootstock, planted in spring 2001 in a randomised block design in 4 replications with 6 trees per plot. Trees were spaced in rows at 1.2 m whereas the distance between rows equalled 3.5 m (2381 trees per hectare). The maidens varied in age from 2-year-old trees (the oldest – their production took 3 years), 1-year-old budded trees (production – 2 years) to 1-year-old grafted trees (the youngest – production took 1 year). The youngest trees were whip grafted during wintertime and dug out from the nursery in autumn of the same year. Irrespective of maiden's age, all trees were without feathers. Pear tree canopies were formed as a spindle with minimum pruning after blooming time and shoots bended down by using concrete weights. The trees were not irrigated and were trained in a V-Güttingen system. Since the first year, there was a herbicide fallow in the rows and sward between them. Chemical protection was carried out according to the current recommendations of the Orchard Protection Programme.

The following data were recorded: growth of trees (trunk cross-sectional area, number and length of annual shoots), yield and fruit quality – mean fruit weight. The circumference of the trunk of each tree (up to third year – diameter) was measured at the height of 30 cm above the level of soil. The obtained results were analysed statistically, using the analysis of variance. Significant differences at P=0.05 were calculated using Duncan's multiple range t-test.

Results and Discussion

Till the 4^{th} year after planting, growth and yield were significantly affected by cultivar and mainly by maiden tree quality. One-year-old budded trees were characterised by the strong vigour of the orchard, while one-year-old grafted trees grew rather weak (especially with 'Carola') – Tab. 1.

Table 1. Vegetative growth of 2 pear cultivars depending on maiden tree quality

Treatment	Trunk cross-sectional area , cm^2			Total number of shoots per tree, 2001-2003	Total shoot length, cm $tree^{-1}$, 2001-2003
	Spring 2001	Autumn 2004	Annual increment		
		Carola			
2-year-old maidens	1.8 d*	15.1 b	4.8 ab	60.2 c	1350 ab
1-year-old budded maidens	1.4 c	18.4 bc	5.8 bc	92.7 d	1801 c
1-year-old grafted maidens	0.6 a	11.4 a	3.8 a	35.7 a	936 a
		Dicolor			
2-year-old maidens	1.0 b	14.8 ab	5.7 bc	37.6 a	1308 ab
1-year-old budded maidens	1.2 b	20.6 c	7.0 c	56.4 bc	1828 c
1-year-old grafted maidens	0.5 a	16.7 b	6.5 c	50.0 b	1558 bc

* Means followed by the same letters do not differ at P=0.05 according to Duncan's multiple range t-test

In comparison with trees planted as 1-year-old budded whips, older ‘Dicolor’ trees grew significantly weaker. In autumn 2004, even grafted ‘Dicolor’ trees were more vigorous. These observations are not consistent with those reported by other scientists (Deckers and Schoofs, 2001; Mika, 2001; Sadowski, 2005). Probably because of the quality of 2-year-old maidens which were not very high (without feathers, rather thin – ‘Dicolor’). Irrespective of age, all planted trees had no laterals. This corresponds with Jacyna’s (2004) opinion, that such is the result of a limited branching capacity of some pear cultivars. Moreover, the root system of older trees could be more damaged and maiden's had bigger stress connected with transplanting. During the first four years of this research, trees planted as 1-year-old budded whips grew stronger as compared with 1-year-old grafted whips. Similar data (trunk cross-sectional area) are presented by Gudarowska and Szewczuk (2003).

In this experiment, pear trees, irrespective of cultivars, started to bear in the third year after planting and higher yields were obtained than in the Błaszczyk (2005) experiment (Tab. 2).

Table 2. Cropping of 2 pear cultivars depending on maiden tree quality

Treatment	Yield, kg tree^{-1}			Cumulative yield, kg tree^{-1}
	2002	2003	2004	
		Carola		
2-year-old maidens	0.1	3.0 b	4.4 ab	7.5 b
1-year-old budded maidens	0.0	5.3 c	5.6 b	10.9 cd
1-year-old grafted maidens	0.0	1.3 ab	2.2 a	3.5 a
		Dicolor		
2-year-old maidens	0.1	1.9 ab	6.1 b	8.1 bc
1-year-old budded maidens	0.0	2.9 b	9.4 c	12.3 d
1-year-old grafted maidens	0.0	0.8 a	6.9 bc	7.7 bc

* Explanation – see Table 1

High productivity of trees on dwarf Quince rootstocks is confirmed by other authors (Kosina, 1997; Iwaniszyniec and Hołubowicz, 1998; Castro and Rodriguez, 2002). On the contrary, according to Loreti *et al*. (2002), yielding of ‘Conference’ cultivar on Quince rootstocks up to sixth year after planting was low. Planting 2-year-old maidens didn’t have positive influence on tree cropping in the orchard. Preliminary results of the study proved that 1-year-old budded trees, irrespective of cultivars, gave the highest yield. The smallest grafted trees yielded less and had the lowest crop efficiency indices (Tab. 3).

Table 3. Mean fruit weight and crop efficiency index (CEC) of 2 pear cvs. depending on maiden tree quality

Treatment	Mean fruit weight, g			CEC, kg cm^{-2}, 2002-2004
	2003	2004	2003-2004	
		Carola		
2-year-old maidens	258 b	207 b	233 c	0.50 b
1-year-old budded maidens	210 a	200 b	205 b	0.59 b
1-year-old grafted maidens	286 b	195 b	241 c	0.31 a
		Dicolor		
2-year-old maidens	189 a	163 a	176 a	0.55 b
1-year-old budded maidens	188 a	152 a	170 a	0.60 b
1-year-old grafted maidens	203 a	160 a	182 ab	0.46 b

* Explanation – see Table 1

Different results were obtained by Gudarowska and Szewczuk (2003). In their experiment, the grafted apple trees, irrespective of rootstock, gave higher crops as compared with the budded ones. Pear cultivars estimated in the experiment differed significantly between each other in mean fruit weight (Tab. 3). Considerably larger fruit were picked from ‘Carola’ trees but “Dicolor’ fruit were not small either, but equalled about 180 g. In contrast, Błaszczyk (2005) reported that ‘Dicolor’ fruit weighted only 108 g. On the other hand, in Czech experiment (Paprštein and Bouma, 1999), ‘Dicolor’ had a fruit weight of just 146 g but, due to the full red blush, it belongs to the most attractive pear cultivars.

Maiden tree quality of both cultivars had no clear influence on mean fruit weight. Only trees planted as 1-year-old budded whips had significantly the smallest fruit due to high productivity in 2003 (third year after planting).

Conclusions

Preliminary results of the four year study proved that estimated new pear cultivars are suitable for commercial production. 'Carola' and 'Dicolor' gave high and early yields as well as good quality fruit.

Maiden tree quality had significant influence on pear tree growth and cropping in the orchard. Till the 4^{th} year after planting, one-year-old budded whips grew strongly and gave the highest yields. Planting two-year-old maidens did not have a positive influence on tree cropping.

Maiden tree quality of both pear cultivars had no clear influence on mean fruit weight.

References

1. Błaszczyk J. (2005) Porównanie wzrostu i początkowego plonowania czterech odmian grusz. XXV Międzynarodowe Seminarium Sadownicze – Limanowa, 71-73.
2. Castro H.R. and Rodriguez R.O. (2002) The behaviour of quince selections as pear rootstocks for 'Abate Fetel' and 'Conference' pear cultivars in the Rio Negro Valley, Argentina. Acta Horticulturae, 596(1), 363-368.
3. Czynczyk A. (1989) Wpływ jakości i wieku sadzonych drzewek jabłoni na przydatność sadowniczą. Ogrodnictwo, 3, 10-13.
4. Deckers T. And Schoofs H. (2001) Management of high density pear orchards. The Compact Fruit Tree, 34(4), 117-120.
5. Ferree D.C. (1976) Effect of rootstocks, propagation method and transplanting on growth and flowering of young apple trees. Journal of American Society Horticulture Science, 101(6), 676-678.
6. Green G.M. (1991) The advantage of feathered trees for more rapid cropping in apples. Pennsylvania Fruit News, 71(4), 25-28.
7. Gudarowska E. and Szewczuk A. (2003) Comparison of grafted apple trees with maidens after planting to the orchard. Folia Horticulturae, 15/2, 131-136.
8. Iwaniszyniec P. and Hołubowicz T. (1998) Wzrost, plonowanie i mrozoodporność drzew w intensywnym sadzie gruszowym. Zeszyty Naukowe AR-Kraków, 333, 439-443.
9. Jacyna T. (2004) The role of cultivar and rootstock in sylleptic shoot formation in maiden pear trees. Journal of Fruit and Ornamental Plant Research, 12, 41-47.
10. Kosina J. (1997) Effect of quince rootstocks on the growth and yields of some pear cultivars in the initial years after planting. Horticultural Abstracts, 7, 717.
11. Loreti F., Massai R., Fei C. and Cinelli F. (2002) Performance of 'Conference' cultivar on several quince and pear rootstocks: preliminary results. Acta Horticulturae, 596(1), 311-318.
12. Mika A. (1995) Dochodowy sad gruszowy. Konferencja gruszowa 'Nowoczesne technologie uprawy grusz'-Skierniewice, 12-15.
13. Mika A. (2001) Jakość sadzonych drzewek jabłoni oceniana w doświadczeniach i przez sadowników. Sad Nowoczesny, 10, 4-5.
14. Oosten H.J. (1978) Effect of initial tree quality on yield. Acta Horticulturae, 65, 123-125.
15. Paprštein F. and Bouma J. (2000) New pears from the Czech Republic. Acta Horticulturae, 538(2), 741-744.
16. Sadowski A. (2005) Warto sadzić drzewka dwuletnie. Hasło Ogrodnicze, 5, 76-79.

PHYSIOLOGICAL FACTORS INFLUENCING THE ROOTING OF PLUM ROOTSTOCKS' HARDWOOD CUTTINGS
PLŪMJU KOKSNAINO SPRAUDEŅU APSAKŅOŠANOS IETEKMĒJOŠIE FIZIOLOĢISKIE FAKTORI

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Kopsavilkums

Izmēģinājumā tika pētīta dažādu tehnoloģisko, fizioloģisko un bioķīmisko faktoru ietekme uz triju veidu koksnaino spraudeņu apsakņošanos. Tehnoloģiskie faktori – spraudeņu griešanas laiks, un ISS optimālā koncentrācija. Augstākā apsakņošanās novērota galvenokārt miera sezonas sākumā vai īsi pirms tās grieztiem spraudeņiem, pielietojot 2000 ppm ISS. Apkārtējās vides ietekme – vidējā temperatūra, aukstuma vienības, kas ietekmēja apsakņošanos netieši. Konstatēta vāja apsakņošanās sakarība ar fizioloģiskajiem faktoriem (lapu nokrišana un plaukšana). Fenolu savienojumu ietekme lapu biršanas laikā un peroksidāzes aktivitātes palielināšanās lapu plaukšanas laikā korelē ar apsakņošanās intensitāti. Polifenolu oksidāzes aktivitāte neietekmēja spraudeņu apsakņošanos.

Abstract

Rooting is a complex process that is determined by the relation of many factors. Rooting rate is highly influenced by the time of cutting collection, which includes the state of the mother plant and the environmental factors on that day.

In our experiment three rootstocks' rooting ability was examined, in relation to the different technological, physiological and biochemical factors. The technological factors were the time of cutting collection, and the optimal dose of IBA. We gained the higher rooting rates mostly in the first half of the dormant season, or before, with applying 2000 ppm IBA. The environmental circumstances that we examined (daily mean temperatures, Cold Units) influenced rooting indirectly. We found a relatively loose connection between rooting and the physiological factors, leaf fall and sprouting. From the state of leaf fall the values of the phenolics that has close correlation to rooting can be suggested, also the peroxidase enzyme activity from sprouting. The third biochemical factor that we examined, the polyphenol oxidase activity did not show any correlation with rooting.

Keywords: rooting, leaf fall, sprouting, water content, temperature

Introduction

Vegetative propagation by hardwood cuttings is a simple and cheap method of the multiplication of plum rootstocks, which has not been used with great success in Hungary so far. The reason for that can be found partially in our climate, and in the Hungarian nurseries' practice. Though applying it to cultivars with more than 50 % rooting rate can be economical (Hartmann *et al.*, 1997). An improvement in propagation technology is needed where the investigations on environmental factors and some biochemical features of mother plants at the time of cutting collection could contribute to progress.

According to literature data, the three rootstock that we examined can root in relatively high percentages, the establishment of 'Sainte Julien GF 655/2' (*Prunus insititia* JUSL.) can be around 70-80 % (Kracikova, 1996; Uzunov, 1987), and 'Marianna GF 8-1' (*Prunus munsoniana* WIGHT & HEDRICK x *Prunus cerasifera* EHRH.) can give almost 100% rooting according to the practice in France (Demol, 2001). The growth reducing apricot rootstock, 'Fehér besztercei' (*Prunus domestica* L.) is a Hungarian selection, a softwood cutting is advised for its propagation; no satisfying results are known when using hardwood cuttings.

In the 1980s, the many studies concerning rooting also focused on almost each of the determining factors of rooting. Besides the environmental and technological factors, however several works studied the roles of the internal processes inside the mother plant, which can be even more determining. The phenological state and biochemical features of the mother plant influence rooting (Bassuk and Howard, 1981, Loreti *et al.*, 1985, Gur *et al.*, 1988, Guskov *et al.*, 1988). It is known that certain materials forming in the plant are related to rooting, but their exact chemical comparison, way of action, and the relation among them have not been clearly defined yet.

Our aim was to examine the phenological state of the mother plant, the environmental conditions on the collecting day, and the different biochemical parameters of the cuttings and buds, in relation to rooting.

Materials and Methods

The open field experiments were carried out in the Experimental Station of Corvinus University of Budapest at Soroksár, where the soil is slightly humic and sandy. The laboratory experiments were performed at the Applied Chemistry Department of the Food Science Faculty of Corvinus University of Budapest. Hardwood cuttings were collected from three rootstocks: 'Marianna GF 8-1', 'Sainte Julien GF 655/2', and 'Fehér besztercei', from September to March during four dormant seasons, then prepared to the length of 25 cm, from the basal part of shoots 7-8 mm in diameter. After collection the cuttings were dipped to fungicide solution, and put to cold storage for one day. Hormone treatment was applied, dipping the base of the cuttings to 50 % alcoholic solution of indole-butyric acid for 5 seconds, using 2000 ppm dose. After the treatment the cuttings were put into wet perlite and stored at 2°C, until planted to open field the next spring.

We examined the ratio of leaf fall, with counting the leaves on marked shoots every week until total leaf fall. For the examination of sprouting cuttings were put to room temperature on each collection date. For measuring the free water content of the cuttings at collection, cuttings were dried at 120°C for three days. The daily maximum and minimum temperature data were used for calculating the daily mean temperatures and cold units, the later was counted by the method of Richardson *et al.* (1974), starting from 23 September. The samples for the biochemical assays were prepared from the cuttings and from the buds of shoots used for the preparation of cuttings. The activity of peroxidase enzyme (POD) was measured by the method of Srivastava (1983), that of polyphenol oxidase (PPO) by the method of Bassuk *et al.* (1981), the determination of the protein content was accomplished by the spectrophotometric way of Bradford (1976). The results are given in Unit^{-mg} protein. The phenolics were assayed by the method described by Singleton and Rossi (1965), the results are given in μg equal to gallic acid^{-mg} fresh sample. Open field experiments were carried out between 1997-2002 during four dormant seasons, while the biochemical investigation between 2000-2003 during three dormant seasons. The results were analysed with one- and two-factor analysis of variance, regression analysis and partial correlation analysis.

Results and Discussion

The comparison of the rooting ability of hardwood cuttings collected on different dates shows a strong effect of timing, which differs among rootstocks. Based on our results, the optimal hardwood cutting collecting period for 'Fehér besztercei' rootstock is the end of October, but in some years cuttings collected in the middle of December can give satisfactory results as well. The hardwood cuttings of 'Sainte Julien GF 655/2' give the best results if collected in the middle of October. For the easily-rooting rootstock 'Marianna GF 8-1' the optimal period for propagation with this method is from the beginning of October until December, but this period can be longer, in some years cuttings collected in January also can root in high percentages (Figure 1.).

The cuttings collected in fall rooted better, this period can be described also with the extent of leaf fall. The quadratic figure fitted on five data pairs at all the three rootstocks reaches its peak at 40-60 % leaf fall. Rooting is supposedly influenced by the weather, the temperature of the collecting days or the period before, through influencing leaf fall. By our point of view, the materials formed in the separating zone of the leaves during leaf fall – first of all phenolics and polyphenol oxidase enzyme – can have an effect on rooting. We could not find clear correlations between the PPO activity measured in the rootstocks' buds and cuttings, but the phenolics content of the buds had square regression relation to rooting in all of the rootstocks. For 'Fehér besztercei' the phenol content in buds over 10 μg/mg, for the Sainte Julien between 10-30 μg^{-mg}, and for the Marianna 10-40 μg^{-mg} resulted a relatively good rooting. In the literature the lower phenol content of the mother plants is said to be favourable (Haissig, 1986), but on the contrary the total phenolics values measured by us were favourable in relatively wide intervals but it is true, that near the measured maximum the rooting dropped (Figure 2.-3.).

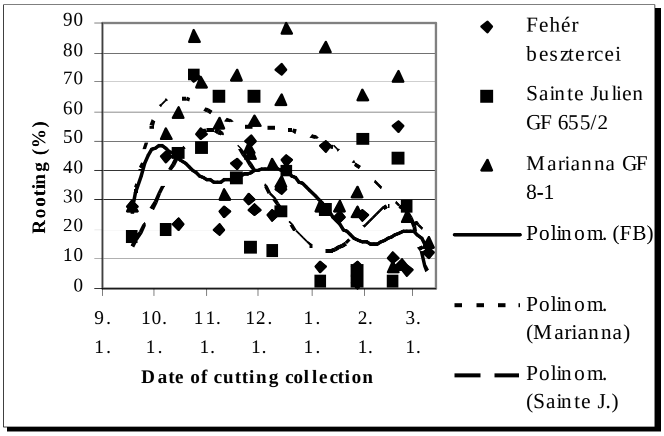

Figure 1. Rooting of plum hardwood cuttings on different dates during four dormant seasons (1997-2002)

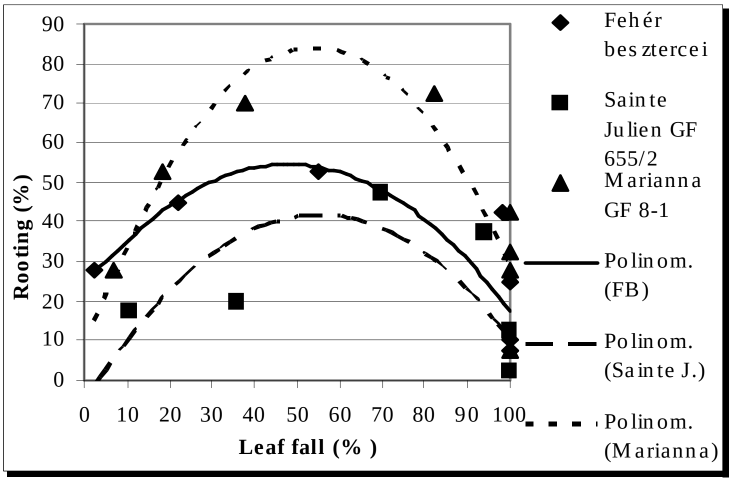

Figure 2. The correlation between leaf fall of mother plants and rooting of plum hardwood cuttings

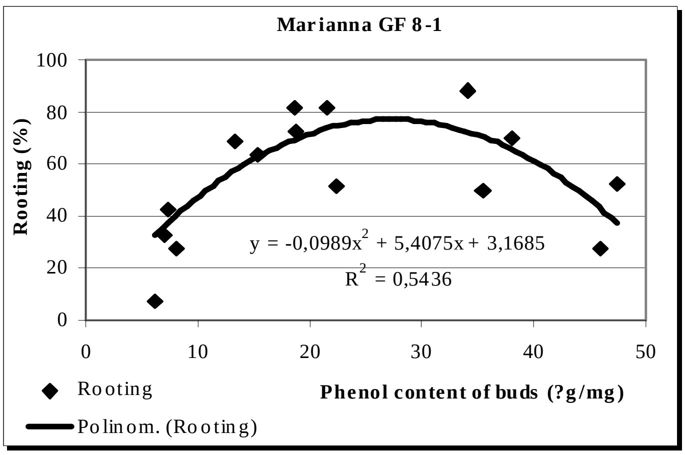

Figure 3. The correlation between phenol content of the buds and rooting of Marianna GF 8-1 hardwood cuttings

According to our results, the water content at collection influences rooting. Though the strength and features of the relation was varying in the years, based on three years' data, higher water content showed to be favourable in all of the three rootstocks. The higher (above 50 %) rooting percentages usually reached when the water content of the cuttings was over 50 %, though lower establishment rates occurred as well. The 50 % water content on collection probably is a limit that under it high rooting cannot be expected.

Statistical analysis did not show significant relation between the rooting of hardwood cuttings and the daily mean temperature at the day of collection in any of the rootstocks. Among the years differences can be seen in the relation between rooting and the cold units (CU) accumulated until the day of collection. The figure fitted to all of the 'Marianna GF 8-1' rootstock's data pairs can be seen that CU under 250 is the best for cutting collection, during this period rooting was over 50%. The material collected later can give good results as well, but the establishment of the cuttings is less certain. The strength of the relation was differing in years for the two other rootstocks, the effect of the year was strong so we cannot use CU data for confident determination of the optimal collecting period (Figure 4.).

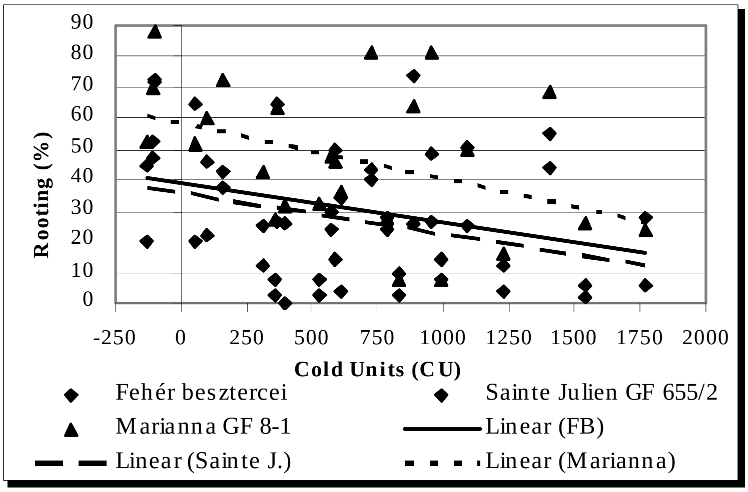

Figure 4. The correlation between Cold Units and rooting of plum hardwood cuttings

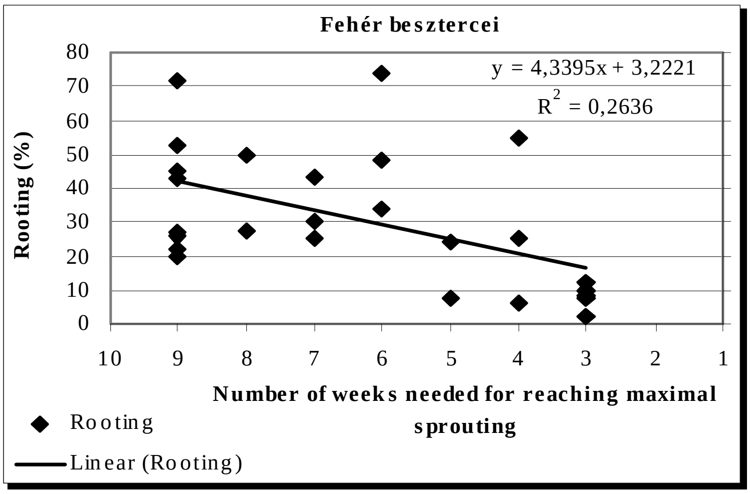

Figure 5. The correlation between the rooting and the number of weeks needed for reaching maximal bud sprouting in 'Fehér besztercei' hardwood cuttings

The dormant state of the mother plants can be described with the capacity of sprouting of their buds. We kept the cuttings for nine weeks at room temperature after collection, recording every week the rate of sprouting buds. The number of weeks needed for reaching maximal sprouting was in linear connection with rooting rate, while the maximal rate of sprouting showed a varying relation. From the correlations analysed we suggested that the extent of sprouting is less important concerning rooting than the time required for sprouting. So the deepest the dormant state of the buds is, the higher rate of rooting can be expected. In the case of 'Fehér besztercei' if sprouting reached its maximal extent in more than five weeks (including when sprouting was not significantly different from 0 after nine weeks), than rooting could be expected above 20 %. In every season examined this need of time decreased less than six weeks in January, the dormant period of European plums ends at this time (Figure 5.).

We found significant correlation between the rooting of all the three rootstocks and the POD enzyme activity measured in one of the organs. The lower activity values were favourable, for 'Fehér besztercei' and 'Sainte Julien GF 655/2' this was under 4 U^{-mg} protein, while for the Marianna rootstock it meant activity under 3 U^{-mg} protein. We have found similar results in the literature, when the cuttings of cultivars with lower IAA-oxidase activity (which is mostly due to peroxidases) rooted better (Guskov *et al.* 1988). But example for the contrary can be found also (Ryugo and Breen 1974). As the POD activity and sprouting had strong correlation, we suggest that POD is one of the biochemical factors that take part in processes resulting sprouting (Figure 6.).

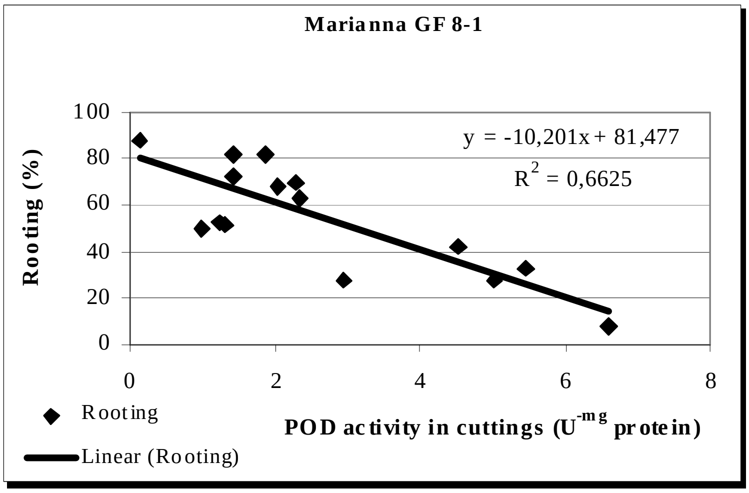

Figure 6. Correlation between POD activity and rooting in Marianna GF 8-1 plum hardwood cuttings

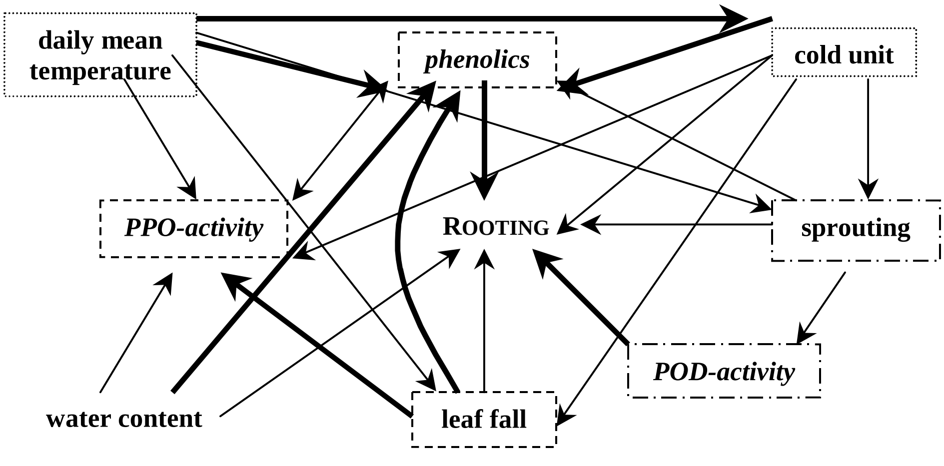

Figure 7. The possible relations between the factors influencing rooting of plum hardwood cuttings (Bold arrows show strong correlations)

Conclusions

Rooting is a complex process that is determined by the relation of many factors. Emphasizing only one factor can be misleading. That is why to the determination of optimal cutting date is complicated, many factors should be considered, and the correlation of factors is variable year by year. The physiological factors have an important role in rooting, but are determined through the biochemical parameters. Rooting rate is highly influenced by the time of cutting collection, which includes the state of the mother plant and the environmental factors on that day. From the statistical analyses among the different parameters measured, the following complex relation system can be suggested, influencing rooting (Figure 7.):

The daily mean temperature and Cold Units derived from it have an effect on almost all examined parameters. Leaf fall is correlated to rooting, but strongly related to phenolics and PPO-activity. These three factors have big influence together on rooting. Water content has only a limiting role, but related to this PPO-phenolics system. Sprouting is a determining parameter, supposedly acting through POD enzyme activity.

References

1. Bassuk N.L. and Howard B.H. (1981) A positive correlation between endogenous root-inducing cofactor acivity in vacuum-extracted sap and seasonal changes in rooting of M26 winter apple cuttings. Journal of Horticultural Science, 56 (4), 301-312.
2. Bassuk N.L., Hunter L.D. and Howard B.H. (1981) The apparent involvement of polyphenol oxydase and phloridzin in the production of apple rooting co-factors. Journal of Horticultural Science, 56 (4), 313-322.
3. Bradford M. (1976) A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Anal. Biochem., 72, 248-257.
4. Demol P. (2001): Oral communication.
5. Gur A., Gad A.E. and Haas E. (1988) Rooting of apple rootstock clones as related to phenols and their oxdation. Acta Horticulturae, 227, 160-166.
6. Guskov A.V., Tikhominov I.A. and Polikarpova F.Ya. (1988) Peroxidase activity in clonal apple rootstocks differing in capacity for rhisogenesis. Fiziologija-Rastenii, 35 (5), 945-954.
7. Haissig B.E. (1986): Metabolic processes in adventitious rooting of cuttings. In: JACKSON M.B. (Ed.) New root formation in plants and cuttings. Dordrecht, Martinus Nijhoff Publishers, 141-189
8. Hartmann H.T. *et al.* (1997) Plant propagation. New Jersey: Prentice-Hall, 770.
9. Kracikova M. (1996) Selection of plum rootstocks for economic propagation by hardwood cuttings. Vedecke Prace Ovocnarske. 15, 41-49.
10. Loreti F., Morini S. and Grilli A. (1985) Rooting response of 'P.S. B2' and 'GF 677' rootstock cuttings. Acta Horticulturae, 173, 261-269.
11. Richardson E.A., Seeley S.D. and Walker D.R. (1974) Model for estimating the completion of rest for „Redhaven" and „Elberta" peach tres. Horticultural Science, 9 (4), 331-332.
12. Ryugo K. and Breen P.J. (1974) Indoleacetic acid metabolism in cuttings of plum (Prunus cerasifera x Prunus munsoniana cv. Marianna 2624). J. Amer. Soc. Hort. Sci., 99, 274-251.
13. Singleton V.L. and Rossi J.A. (1965) Colorymetry of total phenolics with phosphomolytdic-phosphotungstic acid reagents. Am. J. Enol. Vitic., 16, 144-158.
14. Srivastava S.K., Vashi D.J. and Naik B.I. (1983) Control of senescence by poliamines and guanidines in young and mature barley leaves. Biochemistry, 22 (10), 2151-2154.
15. Uzunov A. (1987) Effect of growth regulator treatment on GF655/2 rootstock propagation by hardwood cuttings. Rastenievdni Nauki, 24 (7), 62-66.

THE EFFECT OF ROOTSTOCK ON THE PHYSIOLOGICAL STATUS AND THE STORAGE ABILITY OF 'ELISE' APPLES
POTCELMA IETEKME UZ 'ELISE' ŠĶIRNES ĀBOLU FIZIOLOĢISKAJIEM PROCESIEM UN GLABĀŠANOS

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Kopsavilkums

Piecpadsmit dažādu potcelmu (P 2, P 14, P 16, P 22, NR 47, P 59, P 60, B 9, B 146, B 396, PB-4, M.9 EMLA, M.26, M.27 un M.7) ietekme uz šķirnes ‘Elise’ glabāšanos tika pētīta četras sezonas - no 1999. līdz 2002. gadam. Ražu novācot tika noteikta vidējā augļu masa, mīkstuma blīvums, cietes indekss, šķīstošā sausna un endogēnā etilēna koncentrācija. Svara zudums, augļu blīvumsa, šķīstošā sausna un masas zudumu pakāpe bojājumu dēļ tika noteikta atkārtoti pēc 6 mēnešiem. Vērojama tendence, ka ilgāk saglabā blīvumu augļi uz sarkanlapainajiem potcelmiem (B 9, P 60, B 396, P 59). Augļi no kokiem uz P2 uzrādīja lielāku endogēnā etilēna saturu, bet uz M.27 šis rādītājs bija zemākais. B 9, P 59 un M.27 uzrādīja augstāku Streifa indeksu, kas nosaka vēlāku augļu nobriešanu. Mazākie augļi bija uz PB-4, P 22 M.27 un P 59 potcelmiem, lielākie – uz P 14, M.7 un P 2. Mīkstuma blīvums, etilēna klimaktērija fāzes sasniegšana, gatavības indeksi un augļu kvalitāte atšķīrās pa sezonām.

Abstract

The effect of fifteen rootstocks (P 2, P 14, P 16, P 22, NR 47, P 59, P 60, B 9, B 146, B 396, PB-4, M.9 EMLA, M.26, M.27 AND M.7) on the storability of 'Elise' apples was studied in the 1999-2002 seasons. Measurements during harvest included mean fruit weight, flesh firmness, starch index, soluble solids and internal ethylene concentration. After six months of cold storage, weight loss, firmness, soluble solids and incidence of storage disorders were determined. Trends showing higher firmness values for fruits from trees on red-leaved rootstocks (B 9, P 60, B 396, P 59) were noted. Fruits from trees on p 2 resulted in higher than average internal ethylene content, although values obtained for M.27 were lower than average. b 9, p 59 and m.27 resulted in higher values of the streif index that corresponded with later ripening. The smallest fruits were noted for super dwarfing rootstocks PB-4, P 22 M.27 AND P 59, while the biggest were ON P 14, M.7 and P 2. A low percentage of physiological disorders of fruits was noted for B 9, B 396, P 59 AND NR 47. A high seasonal variation was observed for firmness, climacteric ethylene production, and maturity indices and fruit quality after storage.

Key words: *Malus × domestica*, internal ethylene, firmness, soluble solids, physiological disorders, starch, Streif index, weight loss

Introduction

There is no doubt that the rootstock may have direct or indirect influences on tree growth behaviour (Wertheim, 1998). One of the most important objectives of growers is to control fruit quality using rootstocks. The classic paper of Hatton (1935) showed that fruits from trees on the dwarf rootstock No. 9 (later named M.9) were bigger with better red blush. The rootstock effect on visual quality parameters, such as mean fruit mass, fruit shape and coloration has been shown in many trials performed at different locations (Barritt *et al.*, 1997; Callesen, 1997; Hirst *et al.*, 2001; Loreti, 2001). The internal fruit quality parameters such as firmness, soluble solids content, and acidity are also affected by the rootstock (Fallahi *et al.*, 1985; Autio *et al.*, 1991; Drake *et al.*, 1991; Ben, 1999; Slowinska and Tomala, 2001). Apple fruit mineral composition also depends on the rootstock (Drake et al., 1991; Ben, 1995) and it is well known that apple storage ability strongly depends on their mineral element content (Fallahi, 1988; Tomala, 1997). Therefore, fruit internal quality is closely related to apple storability and may influence fruit maturation (Barden, 1988; Barden and Marini, 1992; Autio *et al.,* 1996).

The objective of this study was to examine the effect of rootstocks of different vigour and origin on fruit internal quality and storability using fruits of the cultivar 'Elise' during the 1999-2002 periods.

Materials and Methods

'Elise' apple fruits from trees on fifteen rootstocks of different vigour and different origin were examined. The trees were budded on P 2, P 14, P 16, P 22, Nr 47, P 59, P 60, B 9, B 146, B 396, PB 4, M.7, M.9 EMLA, M.26, and M.27 rootstocks.

The orchard trial was set up in four replications, with 5 – 7 trees per plot and planted in the spring of 1997. The harvest date was estimated based on the induced ethylene method. At harvest time, flesh firmness was measured using the Instron penetrometer, soluble solid concentration was determined using a refractrometer, and the degree of starch breakdown (starch index, on a 1-10 scale) was assessed. The Streif maturity index was also calculated based on these values. The internal ethylene concentration was determined with a Hewlett Packard gas chromatograph Model 5890 II. All measurements were performed on the random samples of 15 fruits per plot. Mean fruit mass was assessed, based on a sample of 100 apples from each plot.

One box (ca 16 kg) of fruits from each plot was stored at 1°C for 6 months for each of three storage seasons: 1999/2000, 2000/2001, 2001/2002and 2002/2003. The flesh firmness, weight loss, soluble solids and percentage of sound fruits, storage diseases and physiological disorders were determined at the end of each storage season.

Data were subjected to an analysis of covariance, the one-factor model separately for three seasons. The two-factor model was used to compare mean values for three years and determine significance. The confounding effect of the mean fruit mass on the firmness was removed using an analysis of covariance. The data on percentage of fruits with physiological disorders, storage diseases and sound apples were transformed using the Bliss method ($\arcsin\sqrt{x}$).

Results and Discussion

The mean fruit mass was a significant covariate for the fruit firmness at harvest in all years. Adjusted means of firmness (Table 1) showed that rootstock affects this parameter; however, there was no persistent tendency for higher firmness associated with any particular rootstock.

Table 1. Rootstock effect on firmness of ´Elise´ apples at harvest and after storage

Rootstock[1]	Firmness (N; 1 kG = 9.81 N)							
	at harvest				after storage			
	1999	2000	2001	2002	1999	2000	2001	2002
PB 4	94.6	-	84.1	81.6	58.6	-	50.2	53.1
P 22	91.7	-	82.1	77.9	55.6	-	52.4	52.3
M.27	92.5	106.7	84.0	86.8	59.3	65.0	52.5	56.9
P 59	91.9	109.8	81.7	93.7	55.2	66.2	52.1	51.5
P 16	91.0	98.0	80.8	91.1	59.7	63.2	51.4	54.5
P 2	90.4	102.6	84.2	88.6	55.9	63.0	53.7	49.5
M.9 EMLA	94.7	111.6	82.8	90.6	59.0	66.6	53.0	51.2
B 9	94.2	109.3	84.6	94.7	60.9	68.1	51.2	54.1
B 396	89.3	110.0	83.7	97.9	60.5	63.5	54.7	50.1
P 60	94.4	112.1	85.5	102.4	60.7	68.1	54.2	50.9
B 146	89.8	108.4	83.5	86.1	57.8	62.2	51.6	54.1
M.7	94.3	-	85.5	93.7	58.4	-	52.4	48.0
M.26	91.1	110.6	84.8	96.1	57.6	64.6	50.3	50.4
Nr 47	94.2	108.7	82.0	94.0	57.3	65.1	52.4	48.5
P 14	90.2	105.6	83.4	86,9	57.0	65.0	53.2	49.1
p-Value[2]	*0.095*	*0.102*	*0.840*	*0.019*	*0.136*	*0.535*	*0.640*	*0.273*

[1] Rootstocks are listed in increasing TCSA value [2] p-Value is equal to F probability

High variation was observed between seasons, as was also found in research by Fallahi *et al.* (1985) and Autio *et al.* (1996). Trends for higher firmness values for fruits from trees on red-leaved rootstocks (B 9, P 60, B 396, P 59) were noted. This fact could be related to higher Ca content in fruits from trees on these rootstocks (Tomala *et al*., 1999; Slowinska and Tomala, 2001; Chun *et al.*, 2002). The firmness after storage was significantly related (data not shown) to firmness at harvest but it was not possible to detect any strong rootstock effect on this. There was no evidence of a relationship between fruit firmness and rootstock vigour as found in a previous paper by Autio *et al.* (1996).

The percentage of soluble solids content (Table 2) was affected by rootstock. In this case, a high seasonal variation was also observed. There were no higher values of these indices recorded for more dwarfing rootstocks, as reported by Autio *et al.* (1991). It is worth mentioning that in certain specific years the percentage of soluble solids after storage was higher for some red leaved rootstocks, as was also pointed out for the case of fruit firmness.

Table 2. Rootstock effect on soluble solids of ´Elise´ apples at harvest and after storage

Rootstock[1]	Soluble solids, %							
	at harvest				after storage			
	1999	2000	2001	2002	1999	2000	2001	2002
PB 4	14.8	-	12.6	14,6	16.1	-	12.1	14.2
P 22	15.0	-	12.6	14,4	15.5	-	11.6	14.3
M.27	14.6	16.4	11.8	14,5	16.1	16.7	11.7	14.4
P 59	14.6	16.3	11.9	13,6	15.5	17.3	10.9	13.9
P 16	14.7	15.9	12.4	14,4	15.4	16.2	11.2	13.9
P 2	15.0	16.6	12.5	14,4	15.7	16.7	12.3	13.9
M.9 EMLA	14.6	16.7	12.2	13,3	15.3	16.8	11.8	13.9
B 9	15.2	16.0	12.2	12,9	15.3	17.8	11.1	14.1
B 396	14.9	16.9	12.7	13,7	15.6	16.4	12.7	13.7
P 60	15.0	16.5	12.9	13,8	15.8	17.1	12.4	13.6
B 146	14.6	16.6	12.1	13,3	15.4	17.1	11.9	14.0
M.7	14.0	-	12.8	14,2	14.8	-	11.6	13.1
M.26	14.6	15.3	11.8	14,6	15.0	16.7	12.0	13.7
Nr 47	14.9	16.7	12.9	13,8	15.6	17.1	12.2	13.5
P 14	14.0	15.5	11.9	13,2	14.3	16.5	11.8	13.4
p-Value[2]	*0.1774*	*0.0402*	*0.4244*	*0.0941*	*0.0020*	*0.1937*	*0.0022*	*0.0470*

[1,2] See table 1

The Streif index (Table 3) associates all maturity indices, and could be used as a more secure indicator of the fruit ripening process. Rootstock effect varied from year to year, but some rootstocks were consistent in their effect. Specifically, B 9, P 59 and M.27 resulted in higher values of this index and this corresponds with later ripening. Delay of maturity on trees on M.27 was also found by Barden (1988).

Mean fruit mass was affected by rootstock (Table 3), and a trend towards bigger fruits on more vigorous rootstocks was observed. The smallest fruits were noted for super dwarfing rootstocks PB-4, P 22 M.27 and P 59, while the biggest were on P 14, M.7 and P 2.

The rootstock effect on physiological disorders (Table 4) and percentage of sound fruits was significant. The presence of physiological disorders was very high in the first year of the experiment.

The low percentage of physiological disorders of fruits noted for B 9, B 396, P 59 and Nr 47 rootstocks was associated with a high Ca and low K:Ca ratio, as presented in a previous paper for these rootstocks (Slowinska and Tomala, 2001). This is in line with data reported by many authors (Fallahi *et al.*, 1988; Tomala, 1997). There was no evidence of any rootstock effect on weight loss caused by respiration and transpiration.

Table 3. Rootstock effect on Streif index and mean fruit mass of ´Elise´ apples at harvest

Rootstock[1]	Streif index				Mean fruit mass, g			
	1999	2000	2001	2002	1999	2000	2001	2002
PB 4	0.11	-	0.11	0,227	161	-	173	200
P 22	0.09	-	0.13	0,244	160	-	189	220
M.27	0.12	0.16	0.17	0,212	175	144	181	205
P 59	0.10	0.19	0.12	0,189	177	148	172	206
P 16	0.10	0.11	0.10	0,298	173	160	192	207
P 2	0.09	0.12	0.14	0,332	188	169	205	219
M.9 EMLA	0.11	0.15	0.14	0,189	170	147	207	221
B 9	0.11	0.20	0.14	0,201	162	138	210	217
B 396	0.09	0.17	0.11	0,274	195	150	206	211
P 60	0.11	0.13	0.12	0,256	170	152	215	217
B 146	0.09	0.14	0.11	0,295	182	160	201	222
M.7	0.13	-	0.14	0,272	163	-	228	231
M.26	0.10	0.17	0.12	0,260	180	153	212	223
Nr 47	0.10	0.16	0.11	0,216	196	160	199	217
P 14	0.10	0.11	0.11	0,242	185	168	232	252
p-Value[2]	*0.0310*	*0.0054*	*0.0023*	*0.0043*	*0.0885*	*0.1106*	*0.0010*	*0.0667*

[1,2] See table 1

Table 4. Rootstock effect on the percentage of physiological disorders and weight loss of ´Elise´ apples after storage

Rootstock[1]	Physiological disorders, %				Weight loss, %			
	1999	2000	2001	2002	1999	2000	2001	2002
PB 4	17.3	-	1.5	15.1	3.2	-	3.3	3,9
P 22	18.7	-	0.9	6.4	3.1	-	3.2	3,5
M.27	9.8	6.8	0.3	11.6	3.2	4.9	3.1	3,5
P 59	7.3	6.8	2.7	4.5	3.1	4.4	3.4	3,7
P 16	10.2	13.1	2.0	7.5	3.2	3.8	3.2	3,5
P 2	34.4	19.9	1.4	12.6	3.2	4.4	3.0	4,3
M.9 EMLA	9.0	5.7	1.2	4.2	3.3	4.8	3.7	4,2
B 9	8.6	4.7	0.7	3.0	3.0	4.8	3.1	3,8
B 396	18.3	9.0	1.6	5.2	2.9	4.4	2.5	3,7
P 60	14.5	4.4	0.7	4.1	3.3	4.4	3.3	3,6
B 146	16.7	6.8	0.4	9.8	3.2	5.1	3.2	4,0
M.7	14.1	-	10.5	7.1	3.6	-	3.3	4,0
M.26	19.3	6.6	6.8	4.5	3.7	4.6	3.1	3,8
Nr 47	16.3	5.0	3.4	5.4	3.4	4.6	3.3	3,9
P 14	11.1	11.2	5.0	9.1	3.3	4.1	3.6	4,1
p-Value[2]	*0.011*	*0.160*	*0.064*	*0.041*	*0.051*	*0.305*	*0.497*	*0.283*

[1,2] See table 1

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References

1. Autio W.R., Barden J.A. and Brown G.R. (1991) Rootstock affects ripening, mineral composition and storability of 'Starkspur Supreme Delicious' in the 1980-81 NC-140 Cooperative Planting. Fruit Var. J., 45 (4), 247-251.
2. Autio W.R., Hayden R.A., Mickey W.C. and Brown G.R. (1996) Rootstock affects ripening, color, and shape of 'Starkspur Supreme Delicious' apples. Fruit Var. J., 50 (1), 45-53.
3. Barden J.A. 1988. Rootstock effects on maturity, quality, storage life, and physiological disorders of Delicious apples. Compact Fruit Tree, 21, 82-85.
4. Barden J.A. and Marini M.E. (1992) Maturity and quality of ‘Delicious’ apples as influenced by rootstock. J. Amer. Soc. Hort. Sci., 117, 547-550.
5. Barritt B.H., Konishi B.S. and Dilley M.A. (1997) Tree size, yield and biennial bearing relationships with 40 apple rootstocks and three scion cultivars. Acta Hort., 451,105-111.
6. Ben J. (1995) Influence of rootstock on mineral content and storage of apple fruits. Acta Hort., 383, 353-357.
7. Ben J. (1999) Effect of rootstocks on mineral element concentration in ‘Gloster’ apples. Proc. Int. Sem. ‘Apple Rootstocks for Intensive Orchards’ (Warsaw 18-21.08.1999), 13-14.
8. Callesen O. (1997) Testing 20 apple rootstocks. Acta Hort., 451, 137-145.
9. Chun I.J., Fallahi E., Colt M.W., Shafii B. and Tripepi R.R. (2002) Effects of rootstocks and microsprinkler fertigation on mineral concentrations, yield, and fruit color of ‘BC-2 Fuji’ apple. J. Amer. Pom. Soc., 56 (1), 4-13.
10. Drake S.R., Larsen F.E. and Higgins S.S. (1991) Quality and storage of ‘Granny Smith’ and ‘Greenspur’ apples on seedling, M.26, and MM.111 rootstocks. J. Amer. Soc. Hort. Sci., 116 (2), 261-264.
11. Fallahi E., Richardson D.G. and Westwood M.N. (1985) Quality of apple fruit from a high density orchard as influenced by rootstocks, fertilizers, maturity, and storage. J. Amer. Soc. Hort. Sci., 110 (1), 71-74.
12. Fallahi E., Righetti T.L. and Raese J.T. (1988) Ranking tissue mineral analysis to identify mineral limitations on quality in fruit. J. Amer. Soc. Hort. Sci., 113, 382-389.
13. Hatton R.G. (1935) Apple rootstock studies. Effect of layered stocks upon the vigour and cropping of certain scions. J. Pom. Hort. Sci, 13: 293-350.
14. Hirst P.M. and NC-140 Co-operators (2001)E arly performance of ´Gala´ on dwarf and 4 semi-dwarf rootstocks at 24 sites in North America. Acta Hort., 557, 199-205.
15. Loreti F., Massai R., Fei C., Cinelli F. and Cecconi B. (2001) Evaluation of eleven dwarfing apple rootstocks: preliminary results. Acta Hort., 557, 155-161.
16. Slowinska I. and Tomala K. (2001) The rootstock effect on mineral composition and storability of ‘Elise’ apple. Folia Hort., 13/2, 69-74.
17. Tomala K. (1997) Orchard factors affecting nutrient content and fruit quality. Acta Hort., 448, 257-264.
18. Tomala K., Andziak A., Kobusinski K. and Dziuban Z. (1999) Influence of rootstocks on fruit maturity and quality of ‘Jonagold’ apples. Proc. Internat. Sypm. “Apple rootstocks for intensive orchards”, Warsaw-Ursynow, Poland, 113-114.
19. Wertheim S.J. (1998) Rootstock guide. FPO, Wilhelminadorp.

EFFECT OF ROOTSTOCK ON GROWTH AND EARLY BEARING OF FIVE-APPLE CULTIVARS IN ESTONIA
POTCELMA IETEKME UZ AUGŠANU UN RAŽAS SĀKUMU PIECĀM ĀBEĻU ŠĶIRNĒM IGAUNIJĀ

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Kopsavilkums

Izmēģinājums tika ierīkots Polli Dārzkopības institūtā, Dienvidigaunijā, smilšmāla augsnē, 2001. gadā, izstādot viengadīgus stādus. Šķirnes 'Alro', 'Cortland', 'Meelis', 'Sinap Orlovskiī' un 'Talvenauding', kuras potētas uz B9, B396, B545, M26 un E75 potcelmiem. Izmēģinājumā uzskaitīts koku augstums, stumbra diametrs, ziedkopu skaits uz koka un raža no koka. Visas šķirnes ziedēja pirmajā gadā pēc iestādīšanas. Nelabvēlīgu laika apstākļu dēļ pirmajos divos izmēģinājuma gados ražas nebija būtiskas. Tomēr sākotnējie rezultāti ļauj spriest, ka B9, B396, un B545 potcelmi sekmē agrāku ražošanu. Arī šķirnes 'Sinap Orlovskij' un 'Meelis' sāk agrāk ražot.

Abstract

The experiment was carried out on a loamy clay soil at the Polli Horticultural Research Centre in South-Estonia. Apple cultivars 'Alro', 'Cortland', 'Meelis', 'Sinap Orlovskiī' and 'Talvenauding' were tested on B9, B396, B545, M.26 and E75 rootstocks. The trial was established in spring 2001, with 1-year-old whips. Tree height, trunk diameter, number of inflorescences per tree and yield per tree were determined in the experiment. All cultivars bloomed in the first year after planting. The yield, however, remained negligible in the first two years, because of unfavourable weather conditions at the bloom time. Nevertheless, preliminary results indicate that B9, B396, and B545 induce early bearing and that 'Sinap Orlovskiī' and 'Meelis' are precocious cultivars.

Key words: apple, clonal rootstock, cultivar, tree vigour, early yield

Introduction

Apple trees in Estonian orchards are mostly more than 20-year-old and primarily on seedling rootstocks. In the countries where horticulture is more developed, apple trees grafted on clonal rootstocks are used. In the last years, apple trees on vigorous or semi-vigorous clonal rootstocks have been more frequently planted in Estonian orchards and home gardens. Rootstocks A2, MM106 and B118 have been recommended and propagated in our nurseries. Orchards with dwarfing and semi-dwarfing clonal rootstocks are of interest to the Estonian farmers as well. During the past 20 years, different elements of orchard technique intended for apple trees on vigorous clonal rootstocks have been studied in Estonia. Yet high-density apple orchards are still in a development stage. Currently, there are few trials with apple cultivars on dwarfing clonal rootstocks and the area of commercial intensive apple orchards is very small. Most apple growers have limited financial resources and they cannot afford to invest into renovation of their orchards. The establishment of intensive apple orchards has been also delayed due to the missing information concerning suitability of particular dwarfing rootstocks suitable for Estonian conditions.

Apple rootstock breeding programme in Estonia was started in 1954. Jakob Palk selected 87 clones, and 3 of them were included in the list of recommended rootstocks: E56 and E63 (both vigorous) and E20 (semi-vigorous). Palk bred one semi-dwarfing rootstock E75, but it has not been sufficiently investigated (Veidenberg, 1985). The first rootstock testing trials were established at the Polli Horticultural Research Centre in 1987. In the first one, E20, E26, E53, E56, E75 (all Estonian) as well as B233, B490, B545, B118, B396, B9 and MM106 were budded with four apple cultivars. In the second trial the rootstocks E37, E39, E63, B257, B476, B491, M7 and MM106 were budded with two cultivars. It was concluded that rootstocks B9, B396, B476, B491 and E75 produced dwarf trees and that trees grown on B545 and E75 were productive (Haak, 2003).

The aim of the present study was to compare the effect of dwarfing rootstocks (M.26, E75, B9, B545 and B396) on tree vigour and early bearing apple cultivars ‘Alro’, ‘Cortland’, ‘Meelis’, ‘Sinap Orlovskiĭ’ and ‘Talvenauding’.

Materials and Methods

The experiment was established on a loamy clay soil at the Polli Horticultural Research Centre in South-Estonia. One-year-old whips were planted in the spring of 2001. Trees were spaced 4.0 × 2.0 m (1250 trees per ha). Apple cultivars ‘Alro’, ‘Cortland’, ‘Meelis’, ‘Sinap Orlovskiĭ’ and ‘Talvenauding’ were tested on B9, B396, B545, M.26 and E75 rootstocks. There were 4 trees per plot in 5 replications. Apple tree canopies were formed as spindle, with moderate pruning and bending of shoots by use of concrete weights made of concrete. Along the rows weeds were controlled by herbicides and sward in alleyways was regularly mown.

The number of inflorescences present on each tree was counted, and yield per tree was recorded. Trunk diameter, at a height of 30 cm, was measured every year. The results were evaluated statistically using the analysis of variance.

The weather conditions in 2002 and 2003 were unfavourable for cropping of apple trees. The summer 2002 was extremely hot and dry; the total rainfall for the period from the 7th of July till the 31st of August reached only 28,9 mm. The spring of 2003 was colder than usual and a frost of -1.3°C occured in the first decade of June. In 2004, a cool weather in spring was followed by a short heat wave and, at the bloom time, frosts occurred on May 13(-4.5° C), 14 (-3.0° C) and 17 (-1.0° C).

Results and Discussion

The number of blossoms per tree depends on the biological characteristics of a cultivar and the rootstock used. In this trial, all cultivars bloomed in the first year after planting. There were some blossoms present in nearly all rootstock/cultivar combinations. In spring 2002, the most abundant flowering was recorded on Meelis’, while ‘Alro’ and ‘Cortland’ bloomed poorly. Rootstocks significantly affected the intensity of blooming. More inflorescences were found on trees grown on B9 and B545 whereas few blossoms were noted (Figure 1). on those grown on E75 and M.26 rootstocks (Figure 1).

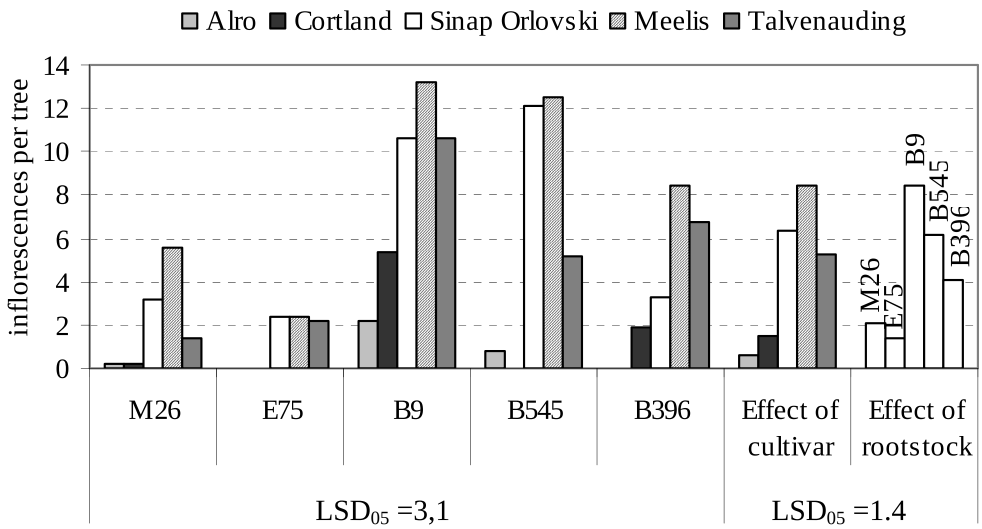

Figure 1. The effect of rootstock and cultivar on blooming in 2002

Trees started to bear fruit in second year after planting. However, the yields of all cultivars on all rootstocks were low. In the first year of bearing, average yields ranged between 0.1 kg per tree (‘Alro’) and 0.7 kg per tree (‘Meelis’). The most precocious cultivar was ‘Meelis’. The early yields were the highest on B9 and the lowest on M.26 and E75 (Figure 2). A relatively high early yield per tree was noted in the following rootstock/cultivar combinations: 'Meelis'/B545, 'Meelis'/B9, 'Meelis'/B396 and 'Talvenauding'/B9.

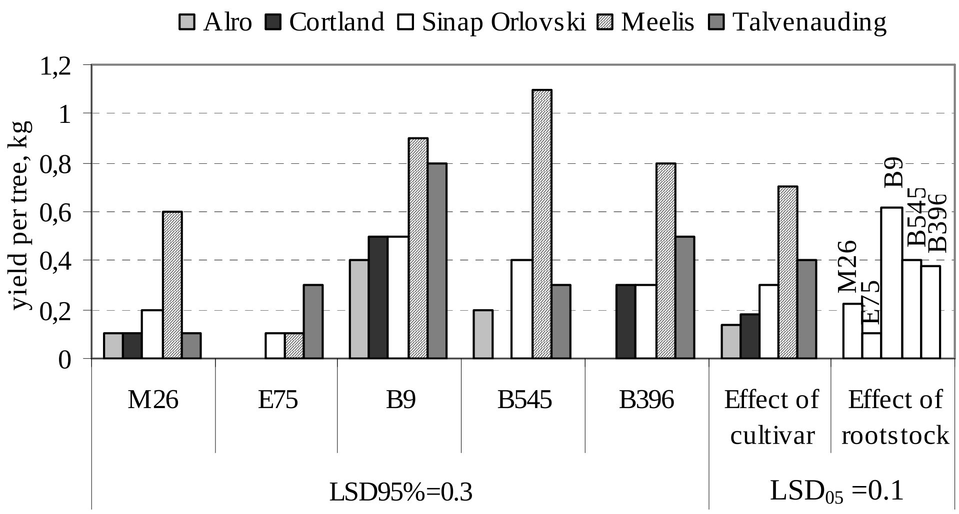

Figure 2. The effect of rootstock and cultivar on early yield in 2002

In 2003, trees of cultivar 'Sinap Orlovskiĭĭ' bloomed more abundantly than trees of other cultivars (Figure 3). Blossoming of cultivars 'Alro', 'Cortland' and 'Talvenauding' was poor. Trees on the rootstock B396 showed a more intense bloom than those on B9 or E75. The most abundant bloom was recorded on the following combinations: 'Sinap Orlovskiĭ'/B396, 'Sinap Orlovskiĭĭ'/B545, 'Sinap Orlovskiĭ'/M.26 and 'Meelis'/B396.

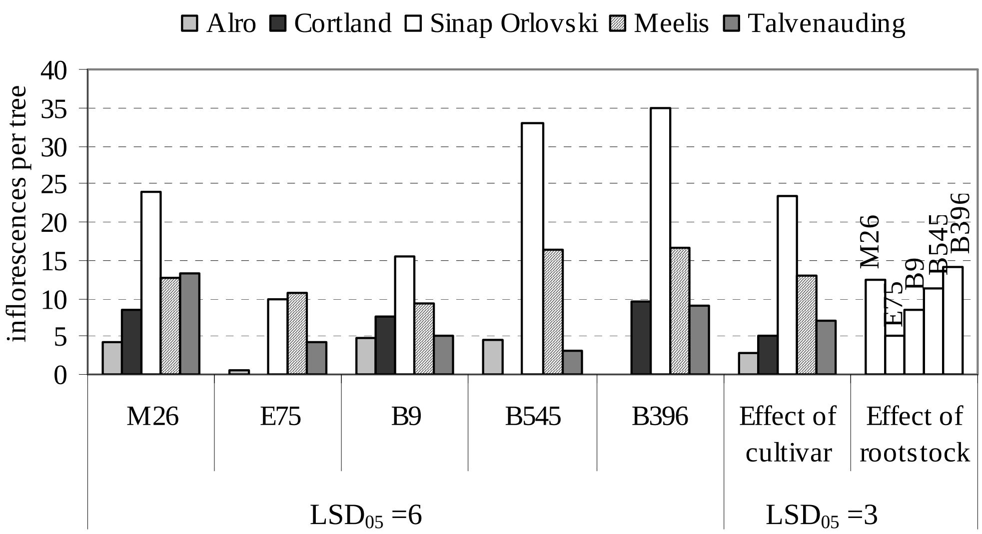

Figure 3. The effect of rootstock and cultivar on blooming in 2003

In the third year after planting in the orchard, trees produced a very low yield because the spring frosts reduced the yielding potential. The trees of 'Sinap Orlovskiĭ' gave a significantly higher yield per tree, compared with the cultivars 'Meelis' and 'Cortland' (Figure 4). Trees, which were budded on the E75 rootstock, cropped poorly. A higher yield per tree was obtained from 'Sinap Orlovskiĭ' on

B396 and from 'Alro' trees on B545 or on M.26. In accordance with the results of Sadowski *et al*. (1999), yield per tree was similar on the rootstocks M.26, B9 and B396.

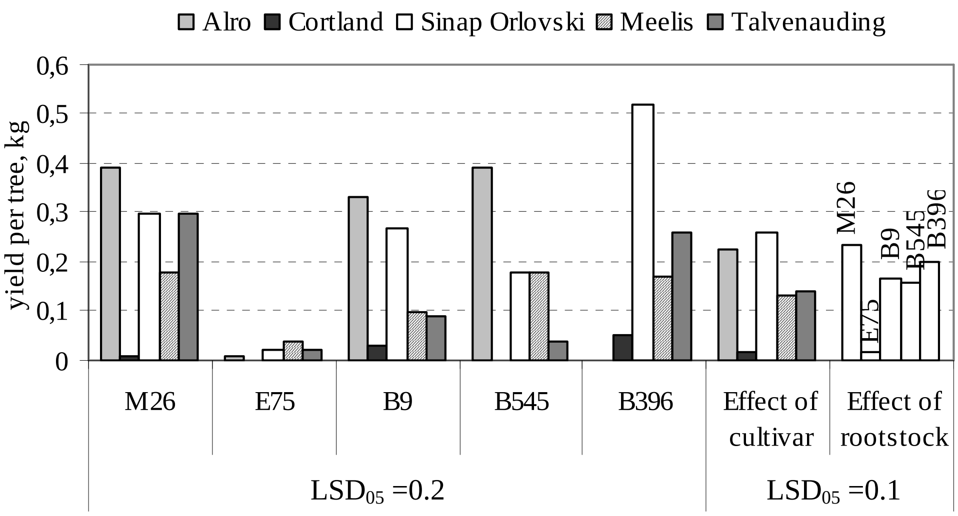

Figure 4. The effect of rootstock and cultivar on yield in 2003

Trunk diameter was used as a measure of tree vigour. In 2003 the mean trunk diameter was 18 mm. Trees budded on B545 always showed the greatest vigour (Figure 5).

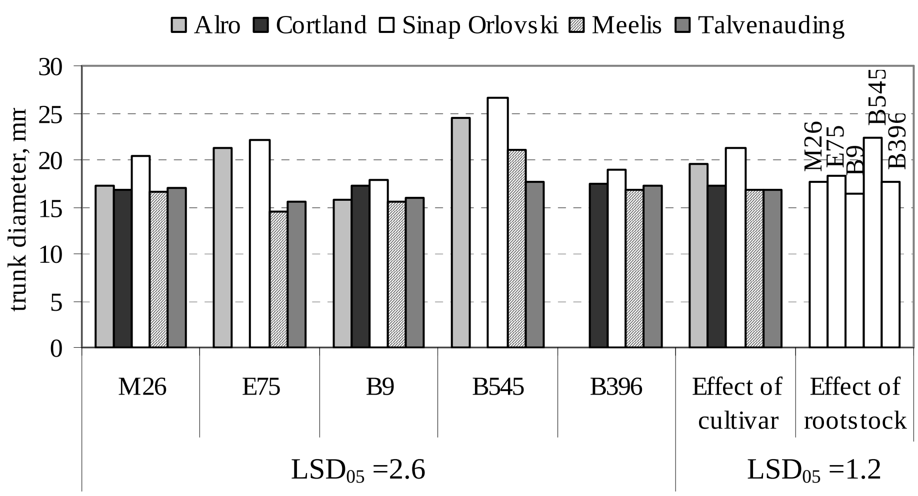

Figure 5. Effect of rootstock on tree vigour in the second year after planting

Trees on B9 were relatively smaller, compared with those on other rootstocks. The trees of 'Sinap Orlovskiĭ' were significantly larger than the trees of other cultivars. 'Sinap Orlovskiĭ' and 'Alro' on B545 and E75 were the most vigorous. After the second year of the trial, no considerable differences in tree size were found between trees budded on M.26 and B396. Similar trends have been reported by Hulko and Hulko (1999), Kurlus and Ugolik (1999), Sadowski *et al*. (1999), and Słowiński and Sadowski (1999).

Conclusions

Under conditions of South Estonia, apple trees on the B545 rootstock are the most vigorous and those on B9 the least vigorous.

Rootstocks B9, B396, and B545 induce early bearing 'Sinap Orlovskiĭ' and 'Meelis' may be classified as precocious cultivars

For more precise evaluation, further studies are needed.

References

1. Haak E. (2003) The effect of clonal rootstocks and interstem to the growth and yield of apple trees. Agraarteadus / Journal of Agricultural Science, 14 (5), 251-259.
2. Hulko I.P. and Hulko B.I. (1999) Orchard performance of apple trees on different clonal rootstocks. In: Sadowski A. (ed.) Apple Rootstocks for Intensive Orchards. Proceedings of the International Seminar, Warsaw-Ursynów, Poland, 43-44.
3. Kurlus R. and Ugolik M. (1999) Effect of rootstocks on growth and yielding of 'Šampion' apple trees. In: Sadowski A. (ed) Apple Rootstocks for Intensive Orchards. Proceedings of the International Seminar ,Warsaw-Ursynów, Poland, 65-66.
4. Sadowski A., Pająk T. and Półtorak W. (1999) Growth and early yield of 'Jonagold', 'Holiday' and 'Fiesta' apple trees on different rootstocks. In: Sadowski A. (ed) Apple Rootstocks for Intensive Orchards. Proceedings of the International Seminar, Warsaw-Ursynów, Poland, 91-92.
5. Słowinski A. and Sadowski A. (1999) Growth in the nursery and in the orchard and initial bearing of 'Elise' apple trees on different rootstocks. In: Sadowski A. (ed) Apple Rootstocks for Intensive Orchards. Proceedings of the International Seminar, Warsaw-Ursynów, Poland, 99-100.
6. Veidenberg, A. (1985) The morphological description of the first 10 apple clonal rootstocks selected in Estonia. Proceedings of the Estonian Research Institute Agricultural and Land Improvement, 61, 14-48 (in Russian).

THE EFFECT OF CLIMATIC AND SOIL CONDITIONS ON THE MINERAL COMPOSITION IN THE LEAVES OF APPLE TREE CULTIVARS DEPENDING ON THE TERM OF THEIR FRUIT RIPENING
KLIMATA UN AUGSNES APSTĀKĻU IETEKME UZ ĀBEĻU LAPU MINERĀLO SASTĀVU ATKARĪBĀ NO ĀBOLU IENĀKŠANĀS LAIKA

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Kopsavilkums
Tika testētas vasaras šķirnes `Jersymac`, `Discovery`, `Geneva Early`, `Close`, `Katia`; rudens šķirnes `Delikates`, `Lobo`, `Novamac`, `Paulared`, `Witos`; ziemas šķirnes `Cox`s Orange` `Pippin`, `Ligol`, `McIntosh`, `Redcroft`, `Shampion`; vēlas ziemas šķirnes `Golden Delicious`, `Gloster`, `Elstar`, `Jonagold Rubin`, visi uz M.26 potcelma. Koki tika stādīti 1992. gada pavasarī, 3.5x1.5 m attālumos. Augstākais minerālvielu saturs tika konstatēts vasaras šķirņu lapās, bet zemākais – vēlo ziemas šķirņu lapās.

Abstract
The objects of the study included apple trees of the following cultivars: summer cvs.: Jersymac, Discovery, Geneva Early, Close, Katia, autumn cvs.: Delikates, Lobo, Novamac, Paulared, Witos, Winter cvs.: Cox`s Orange Pippin, Ligol, McIntosh, Redcroft, Šampion; late winter cvs.: Golden Delicious, Gloster, Elstar, Jonagold Rubin. All trees were planted in spring 1992 on M.26, in 3.5x1.5 m spacing.

The highest content of mineral components was found in the leaves of summer cultivars while the lowest content was found in the leaves of the late winter cultivar group.

Key words: apple cultivars, leaf chemical concentrations

Introduction

Fertilization is one of the most frequently applied agrotechnical treatments in orchards, however, the determination of fertilization needs of orchard plants is very difficult. Fruit trees and shrubs are perennial plants with comparatively low fertilization requirements which are additionally modified by the method of soil use (Neilsen *et al.* 1986, Horning and Bűneman, 1993). Numerous studies have shown the effect of rootstock on the mineral composition of plants as well (Sharma and Chauchan 1991; Tagliavini *et al*., 1992; Chun *et al*., 2001). However, there are no data referring on the effect of cultivars on the mineral composition of the plant. One should believe that the knowledge of these relations might have a significant importance in the determination of the fertilization requirements of orchard trees.

The aim of the studies carried out in the experimental orchard of the Pomological Department on the area of the Agricultural and Pomological Experimental Farm in Przybroda was to investigate the effect of climatic and soil factors on the content of mineral components in apple tree leaves with different terms of fruit ripening

Materials and Methods

The estimation of the mineral component content in the leaves of apple tree cultivars was carried out in the years 2000-2002 in the experimental orchard. The object of the study included apple trees of the following cultivars:

- summer cv.: 'Jerseymac', 'Discovery', 'Geneva Early', 'Close', 'Katia';
- autumn cv.: 'Delikates', 'Lobo', 'Novamac', 'Paulared', 'Witos';
- winter cv.: 'Cox`s Orange Pippin', 'Ligol', 'McIntosh', 'Redcroft', 'Sampion';
- late winter cv.: 'Golden Delicious', 'Gloster', 'Elstar', 'Jonagold', 'Rubin'.

All trees were planted in spring 1992 on M.26 rootstock, in 3.5 x 1.5 m spacing. The trees were grown on proper grey-brown podzolic soil created of medium sand lying on light boulder clay. Thee humus content was about 1.45% and the soil fractions did about 23%. The content of available mineral nutrients in year 2000, was high in reference to phosphorus and magnesium as compared to soil nutrient standards in topsoil and subsoil layers (Sadowski *et.al.*, 1990). For potassium, it was optimal in the topsoil layer and high in the subsoil layer with a correct K:Mg ratio and acid soil reaction (Table 1).

Table 1. Content of mineral compounds in soil in 2000 year, mg per $100g^{-1}$ soil

Soil level	pH	P	K	Mg	K:Mg
0-20 cm	5.4	5.8	10.5	7.8	1.3
21-40 cm	5.1	8.3	8.2	6.9	1.2

All agrotechnical practices including mineral fertilization were carried out as recommended for the commercial orchards.

Leaf sampling was done every year between the 15-th and the 20-th of July in 4 replications from 5 trees, separately for each cultivar (totally 20 trees for each cultivar). Leaves were collected from the middle part of long shoots growing in the central part of the crown. After drying at 70°C, the leaves were ground, wet burnt and the following elements were identified:

- phosphorus - colorimetrically with the use of molybdenum-vanadium mixture
- magnesium and potassium - according to atomic absorption method
- calcium - by atomic absorption in the presence of lanthanum in 1% concentration.

In order to define a correlation between the content of mineral components in leaves and in soil, samples of soil were taken at the same time as leaf samples, separately for the layers of 0-20 and 21-40 cm.

All obtained results were statistically analysed and the significance of differences between the combinations was evaluated on the basis of the confidence interval calculated by Duncan's test for significance level p=0.05. Additionally, linear correlation coefficients were calculated between the climatic conditions and the mineral composition of soil on the one hand and the mineral component content in apple tree leaves on the other hand using the STATISTICA program.

Results and Discussion

Climatic conditions are regarded as natural factors which have a significant effect on tree growth and yielding (Pacholak, Rutkowski 1999). Meteorological data (Table 2) indicate that weather conditions during the experiment (1999-2002) were diversified. It is noteworthy that in comparison with the mean annual temperature, the annual mean temperature as well as the mean temperatures of the vegetation period was higher by 1.4°C and 2.1 °C, respectively. Similarly to temperatures, also the precipitations were different between particular years. In comparison to the mean value of many years the precipitations were lower compared to mean annual precipitation. According to the accepted standards, 3 years (1999, 2000 and 2002) were dry years and one year (2001) was a moderately moist year.

Table 2. Mean temperatures and precipitation sums in 1999-2002 according to Meteorological station in Przybroda

Years	Mean yearly temperature	Mean temperature in growing period IV-IX	Sum of temperatures in growing period IV-IX	Annual precipitation	Sum of rainfalls in growing period IV-IX
	°C			mm	
Mean of 1956-1992	8.1	14.2	2627.0	529.1	326.6
1999	10.2	17.0	3114.0	487.4	262.5
2000	10.6	16.6	3028.6	526.6	295.0
2001	9.1	15.6	2854.8	487.4	317.8
2002	9.9	17.1	3129.3	516.1	229.7
Mean of 1999-2002	9.95	16.6	2806.7	504.4	276.3

The content of mineral components in the leaves of 20 apple tree cultivars was different. This according to Wójcik (1996) may depend on the cultivars, yielding and the weather conditions. Therefore, the interpretation of results was considered with the analysis of the mineral composition of the leaves of the examined summer, autumn, winter and late winter cultivars.

Nitrogen content in leaves, depending on the group of cultivars, was diversified and it ranged from 1.94% DM (dry matter) in the group of late winter cultivars to 2.14% DM in the leaves of summer cultivars. Between the groups of autumn and winter cultivars, no significant differences were found (Table 3). In comparison to standard values, nitrogen content in leaves was low in autumn, winter and late-winter cultivars while in the group of summer cultivars nitrogen content was optimal. Regardless of the cultivars group, significant differences in nitrogen content were also found between the years 2001 - 2002 ranging from 1.93% to 2.10% DM, respectively. Linear correlation coefficients did not show any significant correlation between the nitrogen content in leaves as dependent on climatic conditions or the content of nutritive components in the soil (Table 4). This statement agrees with the earlier results obtained by Pacholak and Zydlik (2003).

Table 3. Content of mineral compounds in leave of apple tree cultivars depending on the term of their fruit ripening in % DM (mean in years 2000-2002)

Groups of cultivars	N	P	K	Mg	Ca
Summer	2.14 c*	0.18 c	1.58 ab	0.35 c	1.36 b
Autumn	2.00 b	0.16 b	1.54 ab	0.32 b	1.26 b
Winter	2.04 b	0.16 b	1.62 b	0.29 a	1.14 a
Late winter	1.94 a	0.15 a	1.51 a	0.35 c	1.59 c
Mean of years:					
2000	2.03 ab	0.15 a	1.28 a	0.33 b	1.41 b
2001	1.97 a	0.17 b	1.71 b	0.37 c	0.96 a
2002	2.10 b	0.17 b	1.70 b	0.28 a	1.63 c

* Mean marked with by the same letters are not significant at the α=0.05

Table 4. Correlation coefficients between climatic conditions and the content of mineral components in the soil and the chemical composition of leaves

Analised factor	N	P	K	Mg	Ca
Temperature	-	-	-	-0.5347 **	0.6634 **
Rainfall	-	-	-	0.5308 **	-0.5765 **
pH topsoil	-	-0.2897 *	-0.5631 **	-0.2676 *	0.4624 **
pH subsoil	-	-0.3052 *	-0.5822 **	-	0.4217 **
P topsoil	-	-0.2897 *	-0.5631 **	-0.2676 *	0.4624 **
P subsoil	-	-0.3508 *	-0.6153 **	-	-
K topsoil	-	-0.2897 *	-0.5631 **	-0.2676 *	0.4624 **
K subsoil	-	-0.2897 *	-0.5631 **	-0.2676 *	0.4624 **
Mg topsoil	-	-0.2854 *	-0.5575 **	-0.2778 *	0.4725**
Mg subsoil	-	-0.2897 *	-0.5631 **	-0.2676 *	0.4624 **
K/Mg topsoil	-	-0.2854 *	-0.5575 **	-0.2778 *	0.4725**
K/Mg subsoil	-	-0.2897 *	-0.5631 **	-0.2676 *	0.4624 **
N content in leaves		-	-	-	-
P content in leaves			-	-	-
K content in leaves				-	-0.3200 *
Mg content in leaves					-
Ca content in leaves					

* Significant difference at α=0.05 *** Significant difference at α=0.01

The content of phosphorus depending on the group of cultivars changed between 0.15% DM in the late winter group of cultivars and 0.18% DM in the leaves of summer group of cultivars (Table 3).

Worthy of attention is the fact that in comparison to boundary values the phosphorus content in leaves of the summer cultivars was a low. The phosphorus content of the leaves showed lowest concentration in 2000 on the average 0.15% DM. In the successive two years, there was no difference. A negative linear correlation was identified between phosphorus content in leaves and the mineral composition of soil and its pH (Table 4). The course of climatic conditions had no effect on the concentration of this component in the leaves of apple trees.

Potassium content in leaves ranged from 1.51% DM in late winter cultivars to 1.62% DM in winter cultivars (Table 3). In comparison with boundary values, independent of the cultivar group, potassium content was at a high level. The analysis of potassium content in the particular years of studies showed a significantly lower K content in leaves in 2000 and the mean value was 1.29% DM The linear correlation coefficients indicated the existence of a negative correlation between potassium content in leaves and the mineral composition of soil and its pH, and a positive correlation with phosphorus concentration in apple tree leaves (Table 4). Similarly as in the case of phosphorus, climatic conditions had no effect on the potassium content in leaves.

Magnesium content in leaves of the analysed groups of cultivars changed between 0.29% DM in winter cultivars, and 0.35% DM in either summer or late winter cultivars. Similarly, as in case of nitrogen, the content of magnesium in the leaves of summer and late winter cultivars in comparison with boundary values, was high, whereas in the autumn and winter cultivars, its content was optimal. The lowest mean magnesium content in leaves was found in 2002 while the highest content occurred in 2001. A negative correlation between magnesium concentration and the content of mineral components in the soil and its reaction was found as well (Table 3). An essential negative dependence was revealed between magnesium in leaves and the temperature in the vegetation period, while a positive dependence was found between magnesium in leaves and the amount of precipitation.

Calcium content ranged from 1.11% DM in leaves of the winter cultivars to 1.54% DM in the leaves of late winter cultivars (Table 3). The remaining groups of cultivars did not differ significantly. The lowest content of calcium was found in 2001 and the highest one in 2002. The linear correlation coefficients indicated a positive dependence on the mineral composition of the soil and its reaction (Table 4). The course of climatic conditions had an effect on the Ca content in apple tree leaves showing a positive dependence on temperature and a negative dependence on precipitation.

The effect of climatic conditions on the content of magnesium and calcium in leaves was found earlier by Pacholak *et al.* (1998) and by Pacholak and Zydlik (2003).

Conclusions

The obtained results permit to state the significant differences in the mineral content of leaves depending on the analysed component and on the group of cultivars. Noteworthy is the fact that independent of the cultivars, the highest content of mineral components was found in the leaves of summer cultivars while the lowest content was found in the leaves of late winter cultivar group.

Linear correlation coefficients between climatic conditions (temperature and precipitations in the vegetation period) and the content of mineral components in the soil and the chemical composition of leaves showed that of climatic conditions influenced and the content of magnesium and calcium in the leaves. Also the content of mineral components in the soil was significantly correlated to the chemical composition of the leaves. Only in case of nitrogen, no effect of climatic and soil conditions on the content of mineral components in leaves was found.

References

1. Chun I., Fallahi E. and Neilsen G. (2001) Net photosynthesis, leaf mineral nutrition, and tree vegetative growth of ‘Fuji’ apple trees on three rootstocks. Acta Hort., 564, 77-82.
2. Neilsen G., Hoque E.J. and Brought B.G. (1986) The effect of orchard soil management on soil temperature and apple tree nutrition. Can. J. Soil Sci., 4, 701-711.
3. Pacholak E., Przybyła C. and Cwynar M. (1998) Nawadnianie i nawożenie a efektywność produkcyjna jabłoni w sadzie po replantacji. Pr. Kom. Nauk Rol. i Leśn. PTPN, 71, 75-83.
4. Pacholak E. and Zydlik Z. (2003) Wpływ nawożenia i nawadniania na zawartość składników mineralnych w glebie oraz liściach jabłoni odmiany ‘Šampion’ w sadzie replantowanym. Pr. Kom. Nauk Rol. i Leśn. PTPN, 95, 281-289.

5. Sadowski A., Nurzyński J., Pacholak E. and Smolarz K. (1990) Racjonalizacja nawożenia i zwiększania produktywności roślin sadowniczych. Instrukcja upowszechnieniowa nr 3 określania potrzeb nawożenia roślin sadowniczych. II Zasady, liczby graniczne i dawki nawożenia, Warszawa.
6. Sharma D.D. and Chouchan J.S. (1991) Effects of different rootstocks and training system on the mineral composition of 'Delicius' apple leaves. J. Hort. Sci., 66, 703-707.
7. Tagliavini M., Scudellari D., Marangoni B., Bastianel A., Franzin F. and Zamborlini M. (1992) Leaf mineral composition of apple tree: Sampling date and effects of cultivar and rootstock. J. Plant Nutr., 15, 605-619.
8. Wójcik P.(1996) Skład mineralny liści drzew sadowniczych a nawożenie. Sad Nowoczesny, 7, 4-6.

PESTICIDE RESIDUE IN SELECTED FRUITS PRODUCED IN POLAND
PESTICĪDU ATLIEKAS POLIJĀ RAŽOTOS AUGĻOS

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Valsts vides piesārņojuma monitoringa ietvaros 8 706 zemeņu, upeņu, aveņu, ābolu, ķiršu un plūmju paraugos tika analizētas pesticīdu atliekas. Pesticīdi tika atrasti aptuveni 30 % no analizētajiem paraugiem. Pesticīdu atliekas virs pieļaujamā līmeņa tika konstatētas tikai 0.57 % paraugu. Neatkarīgi no pētījumu gada pesticīdu atlieku normas netika pārsniegtas avenēm un plūmēm. Reti šīs normas tika pārsniegtas upenēm (1.7 % no upeņu paraugiem) un ķiršiem (1.2 %). Divos pēdējos gados pesticīdu atliekas, kuras pārsniedz pieļaujamās normas, netika atrastas.

Abstract

On the basis of studies conducted within the framework of the State Environmental Pollution Monitoring levels of residues of pesticides were analyzed in 8 706 fruit samples (strawberries, black currants, raspberries, apples, cherries and plums). Pesticides were found in approximately 30% of the collected samples. Crop protection chemicals in the amounts exceeding their admissible residue levels were detected in only 0.57% of the samples of fruit species. Irrespective of the year of the study such irregularities were not observed in raspberry and plum fruits. Pesticide contents exceeding admissible values were most frequently found in black currant fruits (1.7 % total number of samples of this species) and cherries (1.2%). In the last two years of the investigations pesticide residues exceeding their admissible levels were not found in any fruit samples.

Key words: fruit samples, pesticides, admissible residue levels.

Introduction

Pesticides constitute a group of chemical compounds used primarily in agriculture to prevent the development of or to control undesirable plant and animal organisms. Their applications bring obvious benefits. However, due to their possible accumulation in the tissues of consumers some pesticides are considered to cause diseases of the central nervous system or mutagenic changes in cells.

Intensive cultivation of orchard plants requires frequent application of chemical plant protection. In such a case fruits, apart from the necessary constituens, may contain pesticide residues in the amounts creating a potential hazard for the health of consumers. Poland was one of the first European countries, in which at the beginning of the 1970's a monitoring system for pesticide residues in agricultural produce was organized. At present such studies are carried out within the framework of the State Environmental Pollution Monitoring, chapter - Monitoring of Soil, Plants, Agricultural Produce and Foodstuffs. Sample collection and analyses are being carried out at the Institute of Plant Protection based in Poznań and in its several regional laboratories.

The aim of the study was to list and analyse the results of the studies conducted so far on the incidence of pesticide residues in fruits produced in Poland.

Materials and Methods

This study has utilized publications summing up the investigations within the framework of the State Environmental Pollution Monitoring on pesticide residue in orchard production (Dąbrowski *et al.*, 1996, 2003; Nowacka *et al.* 2001; Michna and Szteke, 2001, 2002). Results of analyses concerned pesticide residues in berry fruits - strawberries, currants and raspberries, pome fruits – apples and stone fruits – plums and cherries during the years 1991-2002. The number of samples of the investigated fruit species, showing pesticide residues taking into consideration the highest admissible residue defined in the binding Polish regulations (Rozporządzenie ... 2004) is presented in the form of lists and tables. A list was prepared of biologically active substances which in fruits exceeded the highest admissible residue levels, together with the classification into groups in terms of the field of action and toxicity degree. For this purpose an annually updated list was used including plant protection chemicals admitted for sale in Poland (Register ... 2005).

Results

In the years 1991-2002 a total of 8 706 fruit samples of the analysed species were collected throughout Poland (Dąbrowski *et al.*, 1996, 2003). In at least 30% samples pesticide residues were detected (Table 1). Pesticides were most frequently detected in berry fruits and least frequently – in stone fruits. In the second period of the study, i.e. in the years 1996-2002 in comparison to the early 1990's the mean percentage of fruit samples containing residues of plant protectants decreased slightly to 29.7% (Table 1). The number of such samples from apples and black currants decreased significantly. Both in the first and the second study period fungicide residues were detected most frequently in fruits. The percentage of insecticide residues founds was much lower (Dąbrowski *et al*. 1996, 2003).

Table 1 Percentage of fruit samples with pesticide residues in the years 1991-2002 (based on Dąbrowski *et al*., 1996, 2003; Nowacka *et al.*, 2000, 2001)

Lp.	Species	Years of investigation		Average for 1991-2002
		1991-1995	1996-2000	
1	Apple	32,0	20,0	26,0
2	Raspberry	40,0	45,0	42,5
3	Black currant	43,0	35,0	39,0
5	Plum	17,0	21,0	19,0
6	Strawberry	45,0	39,0	42,0
7	Cherry	14,0	18,0	16,0
	Average	31,8	29,7	30,8

The mere presence of plant protection chemicals in fruits does not mean that these fruits constitute a hazard for the health of consumers. This may happen when the content of pesticides exceeds a certain threshold value – i.e. the highest admissible residue. In the years 1991-2002 out of over 8 thousand analysed fruit samples only in 0.57% of them plant protection chemicals occurred in amounts exceeding the highest admissible residues (Table 2). Raspberries and plums turned out to be safest for consumers. Pesticide residues in amounts higher than their highest admissible residues were not found in any samples from these species. Such residues were detected most frequently in cherry and black currant fruits. However, the numbers of samples with exceeded highest admissible residues constituted not more than 1.7% of the total number of samples analysed in these species (Table 2).

Table 2 Percentage of fruit samples with pesticide residues in the amounts exceeding the highest admissible residues in the years 1991-2002 (based on Dąbrowski *et al.*, 1996, 2003; Nowacka *et al*., 2000, 2001)

Lp.	Species	Years of investigation		Average for 1991-2002
		1991-1995	1996-2002	
1	Apple	0,2	0,6	0,4
2	Raspberry	0	0	0
3	Black currant	1,3	2,1	1,7
4	Plum	0	0	0
5	Strawberry	0,3	0	0,2
6	Cherry	1,5	0,8	1,2
	Average	0,55	0,58	0,57

In the second period of the study in comparison to the years 1991-1995 the number of samples from strawberries and black currants containing plant protection chemicals in the amounts exceeding the highest admissible residues increased noticeably (Fig. 1).

In contrast, the quality of apples and cherries improved significantly. In the last two years of the study, i.e. 2001 and 2002, irrespective of the fruit species, in no samples the highest admissible pesticide residues were exceeded.

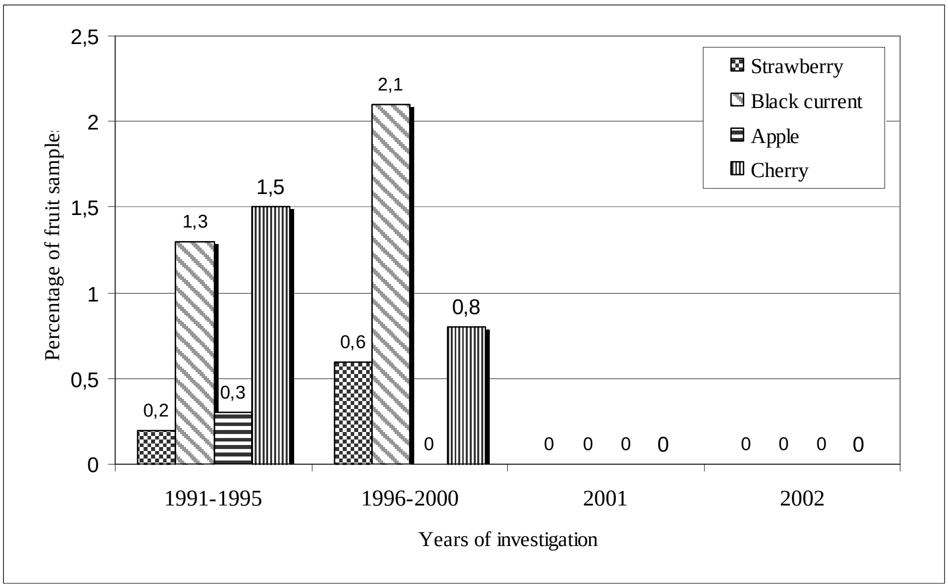

Figure 1. The trend in percentages of fruit samples with pesticide contents in the amounts exceeding the highest admissible residues in the years 1991-2002 (based on Dąbrowski *et al.*, 1996, 2003; Nowacka *et al.*, 2000, 2001)

Table 3 contains a list of biologically active substances found in fruits in amounts exceeding the highest admissible residues. It results from this list that in fruits (especially in apples) most frequently insecticides exceeded their highest admissible residues.

Table 3 Biologically active substances detected in fruits in the amounts exceeding highest admissible residues in the years 1991-2002 (based on Dąbrowski *et al.*, 1996, 2003; Nowacka *et al.*, 2000, 2001)

Lp.	Species	Biologically active substances	Number of samples	Kind of preparation[1]	Class of toxicity	
1	Apple	Dichlorfos	2	insecticide	II	toxic
		Fenwalerat	2	insecticide	III	harmful[1]
2	Black currant	Alfametryna	2	insecticide	IV	residual
		Bromopropylat	4	insecticide	-	-
		Ditiokarbaminiany	17	fungicide	IV	residual
		Endolsulfan	1	insecticide	II	toxic
3	Strawberry	Permetryna	2	insecticide	IV[3]	residual
		Lenacyl	1	herbicide	IV	residual
		Dichlofluanid	1	fungicide	IV	residual
		Ditiokarbaminiany	7	fungicide	IV	residual
		Alfametryna	1	insecticide	IV	residual
		Symazyna	1	herbicide	IV	residual
4	Cherry	Chlorotalonil	1	fungicide	IV	residual
		Ditiokarbaminiany	1	fungicide	IV	residual
		Kaptan	2	fungicide	IV	residual
		Metydation	4	fungicide	IV	residual

1 – according to Rejestr ... 2005; 2 – according to Ustawa ... 2003;
3 - according to Ustawa z dnia 12.07.1995 roku o ochronie roślin uprawnych (Dz. U nr 90, poz. 446)

According to the classification introduced by the revoked Act of 12 July 1995 on crop plant protection they are compounds of toxicity class II or III, or according to the toxicity classification of the currently binding Act of 18 December 2003 on crop plant protection (Act of ... 2003) – they are included in the group of toxic and harmful compounds. However, all the fungicides found in fruits (especially cherries) are included in a not very toxic class IV or the group of “other compounds”. The same group of toxicity includes also two biologically active substances of the herbicide group detected in amounts exceeding the highest admissible residues in strawberry fruits.

Discussion

Plant protection measures are taken with special intensity on crop plants in orchards and plantations of berry fruits. Considering the national consumption of plant protection chemicals in agriculture amounting to 0.5-0.75 kg active ingredient$\cdot ha^{-1}$, in apple orchards this amount increases to 15.8-38.3 kg active substance$\cdot ha^{-1}$. Similarly on plantations of berry-bearing plants (especially black currants) the amounts of applied pesticides exceed 20 kg active ingradiant$\cdot ha^{-1}$ (Ilnicki, 2004). However, these fruits are not included in the group of plants accumulating the highest amounts of plant protectants. According to the results of the State Environmental Pollution Monitoring, among the several dozen tested agricultural products the highest admissible residues were exceeded most frequently in vegetables, especially those produced under cove (Michna and Szteke, 2001, 2002; Ilnicki, 2004). In spite of the fact that in the years 1991-2002 residues of plant protection chemicals were found in approx. 30% analysed fruit samples (Table 1), only in 0.57% samples the highest admissible residues were exceeded (Table 2). In fruits of some species no exceed of the highest admissible residues were detected at all. Raspberries and plums may serve as examples here (Table 2). In the years 1991-2002 instances of such high residues were most frequently detected in fruits of black currant (especially in the late 1990’s) and cherry (Fig. 1). However, it needs to be stressed here that the numbers of both cherry and black currant fruit samples which exceeded highest admissible residues of pesticides constituted not more than 2% total quantity of analysed fruit samples within these species and most of the detected plant protection chemicals consisted of relatively unstable fungicides included in toxicity class IV (the group of “other compounds”) (Table 3).

The share of cherries and black currants in the species structure of Polish fruit production is definitely smaller than that of apples. Apples constitute 60 to70% Polish fruit crops (Związki, 2000). Their quality in terms of the exceeded admissible contents of plant protectants is gradually improving. While in the years 1991-1995 in fruits of this leading species, the highest admissible residues were exceeded primarily by stable insecticides classified as harmful and toxic (Table 3), in the second period of the study exceeded admissible pesticide contents were not detected in any apple sample (Figure 1).

Especially in the last two years of the study, i.e. 2001 and 2002, the quality of pomiculture production in Poland in terms of pesticide residues distinctly improved. Due to the increasingly frequent application of Good Agricultural Practice and promotion of Integrated Fruit Production such a situation is to be expected.

The very small number of samples of berry, stone and pome fruits exhibiting pesticide contents in the amounts exceeding their highest admissible residues (Table 2) and a distinct decreasing trend in the number of such samples (Fig. 1) made it possible to conclude that consumption of fruits produced in Poland poses only a slight threat to the health of consumers.

Conclusions

In the years 1991-2002 in approx. 30% fruit samples residues of plant protectants were found. They were detected most frequently in berry fruits and least frequently in stone fruits.

In terms of pesticide contents the quality of fruits produced in Poland has to be considered as good. Pesticide residues in the amounts exceeding their highest admissible values were found in less than 1% of the analysed samples.

Among the six analysed fruit species no excess of the highest admissible residues of pesticides were found in raspberry and plum fruits.

Insecticides are the most frequent biologically active substances detected in fruits in the amounts exceeding their highest admissible residues. All the detected fungicides belonged to the not very toxic class IV.

In the last two years of the study a distinct improvement was observed in terms of pesticide residues in fruits.

References

1. Dąbrowski J. Gąsior J., Janda T. and *et al*. (1996) Obraz skażeń pozostałościami pestycydów upraw rolnych i gleb w Polsce w latach 1991-1995. Postępy w ochronie roślin, 36(1), 57-76.
2. Dąbrowski J., Nowacka A. and Gnusowski B. (2003) Kontrola pozostałości środków ochrony roślin w Polsce w latach 1996-2002. Postępy w ochronie roślin, 43(1), 86-93.
3. Ilnicki P. (2004) Polskie rolnictwo a ochrona środowiska. Wydawnictwo AR w Poznaniu, Poznań.
4. Michna W. and Szteke B. (red.) (2001) Raport z monitoringu jakości gleb, roślin, produktów rolniczych i spożywczych w 2000 roku. Ministerstwo Rolnictwa I Rozwoju Wsi, Warszawa.
5. Michna W. and Szteke B. (red.) (2002) Raport z nadań monitoringowych jakości gleb, roślin, produktów rolniczych i spożywczych w 2001 roku (wersja skrócona). Ministerstwo Rolnictwa I Rozwoju Wsi, Warszawa.
6. Nowacka A., Dąbrowski J., Drożdżyński D. and *et al*. (2001) Pozostałości środków ochrony roślin w płodach rolnych. Postępy w ochronie roślin, 42(1), 254-261.
7. Rejestr środków ochrony roślin dopuszczonych do obrotu i stosowania zezwoleniem Ministra Rolnictwa i Rozwoju Wsi. 2005. Min. Roln. i Rozwoju Wsi., Warszawa (http://www.minrol.gov.pl).
8. Rozporządzenie Ministra Zdrowia z dnia 16 kwietnia 2004 roku w sprawie najwyższych dopuszczalnych poziomów pozostałości chemicznych środków ochrony roślin, które mogą znajdować się w środkach spożywczych lub na ich powierzchni (Dz. U. z 2004 r., No. 85, poz. 801).
9. Ustawa z dnia 18.12.2003 roku o ochronie roślin uprawnych (Dz. U. z 2004 r. No. 11, poz. 94).
10. Związki komplementarne i konkurencyjne unijnego i polskiego sadownictwa u progu integracji europejskiej. 2000. Centralny Ośrodek Badań Rozwoju Ogrodnictwa, Warszawa.

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