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Professori
Mauri Olavi Meurmanin juhlajulkaisu

Jubilee issue in honour of
Professor Mauri Olavi Meurman

HELSINKI 1977

Professor Mauri Olavi Meurman
Head of the Institute of Horticulture in 1927—1960

The Agricultural Research Centre has dedicated this issue to Professor Mauri Olavi Meurman, in appreciation of his distinquished career as a scientist and of his work as a founder and, for many years, as director of the Institute of Horticulture.

Olavi Meurman was born at Ilmajoki on July 19th, 1893. He entered the Normal Lyceum, Helsinki, in 1903 and became an undergraduate in 1912. At school, inspired by his famous teacher K. E. Kivirikko, he became very interested in natural sciences which, after matriculation, he studied at university with botany as his major subject. After receiving his Bachelor of Arts degree in 1916, he continued his studies at the Faculty of Agriculture of the University of Helsinki.

In 1919 Meurman became director of the Plant Breeding Department of Agros Ltd. and then department manager at the Finnish Seed Company Ltd., where he continued until 1923. In 1924—25 he took the degree of Candidate of Horticulture at the Agricultural High School, Denmark. At the same time, under Professor Winge in Copenhagen, he carried out cytological research work resulting in a doctorial dissertation on the sex chromosomes of plants. It was published in 1925. This was followed by the directorship at the Häme Experiment Station. In 1927 Meurman was appointed Docent of Applied Genetics at the University of Helsinki. The same year he also took on the directorship of the Agricultural and Horticultural Experimental Station of Southwest Finland which was founded at Yltöinen, Piikkiö. In 1935, when the Experimental Station became the Horticultural Department of Agricultural Research Experiments, he became a professor and manager of the Department. It was here, at the Institute in Piikkiö, that Professor Meurman carried out what could be called his life's work, between 1927—60, as the pioneer of horticultural research in Finland.

As early as 1925 he had been asked to investigate the possibility of setting up horticultural research in Finland. He was already familiar with tasks of this type thanks to his earlier association with similar projects in other Nordic countries, especially in Denmark. The same year he was asked to look for a state-owned farm that would be suitable as a horticultural experimental station. The Yltöinen farm at Piikkiö proved to be most suitable of those available.

Energetically, Meurman at once started to develop the farm into an experimental station. Before the Yltöinen farm could be ready for use, large basic improvements had to be made, such as clearing and building. It should be remembered that only a limited sum had been granted for the foundation and maintenance of the experimental station. Such circumstances demanded a founder of exceptional enterprise. The Experimental Station was not, however, allowed to be devoted entirely to horticultural experiments and research. At the beginning its duties consisted primarily of experiments with field plants, horticultural experiments taking second place. When the Station became an Institute in 1935 field plants were still included in its programme. Only when the organisation became the Agricultural Research Centre, in 1956, could the Institute of Horticulture devote itself entirely to horticultural research.

Professor Olavi Meurman's research was divided into two fields. His earlier interest and publications were dominated by cytology and genetics, while later on horticultural research became his main subject. This is quite natural, since it took time before his research especially with perennial garden plants, was ready for publication. The publications on cytology and genetics which made him an internationally known scientist appeared in 1924—46.

In his doctorial dissertation "The Chromosome Behaviour of Some Dioecious Plants and Their Relatives with Special Reference to the Sex Chromosomes", published in 1925, Meurman dealt with the chromosomes that determine the sex of the plant. Before this only a few, contradictory facts were known about this subject. Meurman noted sex chromosomes in eight new plant species and confirmed a number of earlier discoveries. He threw considerably more light on this matter. In 1926 he published his investigations into the heredity of characteristic features in oats. This was followed in 1928 by extensive research into the cytology of the *Ribes* genus. In this look he clarified the number of chromosomes in 29 species, discovering that they numbered 16 when diploid. Further, he discovered that the affinity of homologous chromosomes of hybrids of different species depends on the size of the chromosomes. Chromosomes of the same size have a close affinity, while those of different size have a poor one. This also determines the fertility of hybrids. In sterile hybrids the affinity proved to be poor. In 1929 Professor Meurman carried out research on *Aucuba japonica* in which, by studying the mother cells of pollen, he resolved and confirmed the theory of replacement of the chromosome segments by showing that the attachment of chromosomes depends on the rearrangement of their fragments. The same year his research into the *Prunus laurocerasus* species was published. This species, which has an exceptionally large number of chromosomes, 170—180, proved to be multiply polyploid. The haploid number of chromosomes in the *Rosaceae* family is 8; thus the number in this case is twenty-two times the basic number. Due to the irregularity of meiosis, the haploid basic number generally varies from 3 to 7. This, however, does not harm the vitality of the species. In 1932, his joint research with Gunnar Rancken into the chromosomes of potato varieties was made known, followed by research into the secondary conjugation of the maple chromosomes in 1933. In 1939, together with Eeva Therman, Meurman published a study concerning the cytology of the *Clematis* genus, in which the effect of structural changes in chromosomes on the fertility of pollen was discovered. Another joint project of these workers was research into the chromosomes of the *Montbretia* species, in 1946.

In the actual field of horticulture, Meurman was especially interested in fruit cultivation research. During the early stages of the Experimental Station and of the Institute, general interest was directed towards the cultivation of fruit and berries rather than of vegetables or flowers. When the experimental fields at the Station were ready and their drainage complete, Professor Meurman started a collection of pomological varieties, in which varieties of apple trees were particularly predominant. The first experimental trees could be planted in the spring of 1932. Alongside the variety trials, experiments with different growing techniques were established including soil management, planting depth and the pruning of apple trees. Professor Meurman was on good terms with the East Malling Research Station in England, which promptly provided new EM rootstock for the trials. These rootstocks were in very great demand throughout the apple-cultivating world. In addition to the fruit tree trials, experiments with black currant and other soft fruits were established. At the same time trials with the most important vegetables were started. Greenhouse experiments showed that with artificial light cucumber plants grew bigger and yielded an earlier crop than with daylight alone. In addition to the experiments and research carried out with cultivated plants, Meurman paid attention to the development of the park area of the farm. A large assortment of different trees and shrubs were planted in the park and their growth and hardiness were observed.

The horticultural research work started by Olavi Meurman soon began to yield results which influenced cultivation in practice. In 1941 the first standard varieties of fruit trees were selected for Finland on the basis of the experiments at the Institute. Among them there were apple varieties which are still cultivated today, such as Canadian 'Lobo' and 'Melba'. Meurman was chairman of the Standard Committee; he also drafted a publication on standard varieties. The control of standard varieties was supervised by Meurman in 1950. At that time he published a book on new standard varieties, "Our Fruit Trees and Berries". Before this, in 1943 and 1947, in collaboration with Olavi Collan, a pomologist, Meurman had published a large work in two volumes: "The Fruit Trees and Cultivated Berries of Finland", the main sources of information for this book being experiments carried out at the Institute. In 1950 he gave out a manual "Pruning Apple Trees" which appeared in Swedish the following year. In this manual he presented the advantages of the American system of apple tree pruning compared with the system in general use, that had been developed in Sweden. This latter system consists of regularly shortening leader shoots and pruning the lateral spurs of young apple trees. Meurman showed that this delayed the tree in reaching cropping age compared with the American system, in which you avoid shortening yearly shoots, the main emphasis of pruning being on the development of a well formed crown. He also studied the effect of planting depth on apple trees and noted that deep planting, when the union of scion and rootstock is about 10 cm below the surface, is more advantageous for cropping than planting so that the union is at the soil surface or about 10 cm above it. Meurman considered the study of apple rootstocks very important. The first rootstock material established in Piikkiö from vegetatively propagated apple trees of English Malling types, and the experiments with them established in 1941, were destroyed by the severe winters of 1941—43. Valuable information on the hardiness of the material was, however, obtained. Types M 9 and M 4 sustained the greatest damage and mortality. After this, experiments established in different regions showed that trees grafted on seedling rootstocks were hardier in winter and were more productive than the trees on M rootstocks.

Professor Meurman also worked on the breeding of soft fruits. His idea was to cross red raspberry and nectar berry (*Rubus arcticus* L.), thus producing a new plant that would be easy to cultivate and would yield berries with the fine flavour of the nectar berry. This kind of crossbreeding succeeded in 1939. Following many years of breeding work the Institute of Horticulture introduced a nectar raspberry, 'Heija', to growers in 1975.

Olavi Meurman was known to be a most interesting personality. He was lively, enthusiastic and sharp-witted, with keen discernment. He had a genius for recognising the essential features of a matter, whether in something practical or in a research result that was difficult to interpret. When instructing, he sometimes exaggerated to get his message across more quickly. Through his charm, his outgoing personality and good knowledge of languages, he became widely known both at home and abroad. On his study trips to the USA, Canada and many European countries, and at the numerous conferences he attended, he built up good contacts with different research institutes and their leading researchers. These contacts were of great advantage to the Institute. They helped to forward co-operation between researchers at different institutes and the exchange of results and material. Meurman's published works were extensive, consisting of about 300 horticultural publications in different series and periodicals in addition to the cytological and genetic publications and pomological manuals mentioned above.

Meurman acted as Finnish representative on the organizing committee of the International Horticultural Congress, as chairman of the Horticultural Section of the Scandinavian Agricultural Society and, for ten years, as the president of Societas Genetica Fennica and of the delegation of the Finnish Horticultural Association. He was a member of several Finnish and foreign societies. He became an associate member of the Finnish Academy of Science in 1929 and a full member in 1945. The Swedish Academy of Agriculture invited him to join its membership in 1948. He was elected an honorary member of Societas Genetica Fennica, the Finnish Horticultural Association, the Finnish Pomological Association and the Swedish Pomological Association. He was awarded the silver Kairamo medal of the Vanamo Society in 1957, and the highest honours of the Finnish Cultural Fund and the Emil Aaltonen Foundation. On his 75th birthday, on July 19th, 1968 an Olavi Meurman medal was cast in his honour.

Professor Olavi Meurman retired in 1960. He died on All Saints' Day, November lst, 1969 at his home in Piikkiö at the age of 76.

Jaakko Säkö

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INHERITANCE OF CHARACTERS IN HYBRIDS OF VACCINIUM ULIGINOSUM AND HIGHBUSH BLUEBERRIES

HEIMO HIIRSALMI

HIIRSALMI, H. 1977. **Inheritance of characters in hybrids of Vaccinium uliginosum and highbush blueberries.** Ann. Agric. Fenn. 16:7—18. (Agric. Res. Centre, Inst. Hortic., SF-21500 Piikkiö, Finland.)

The results obtained with trial plantings of the highbush blueberry in Finland have not been sufficiently good to justify the commencement of commercial cultivation. All the varieties are susceptible to frost damage and the blueberry canker caused by the fungus *Fusicoccum putrefaciens* Shear.

At the Institute of Horticulture at Piikkiö, attempts are being made to develop highbush blueberries better suited to climatic conditions at northern latitudes by crossing varieties with native *Vaccinium* species. So far, successful crosses have been made only with *V. uliginosum* L.

The F_1 generation clearly possesses the unfavourable gene combinations typical of crosses between two widely separate species, which in time can cause a great variety of disturbances. This is evident in weakened vigour and, for instance, a consequent decrease in winter hardiness and fruit yield. The F_1 generation has thus failed to provide any individual that is suitable for commercial cultivation.

When the F_1 individuals are back-crossed with the highbush blueberry varieties, the unfavourable gene combinations are at least partly eliminated. A number of fairly promising individuals have been obtained, in which winter hardiness and resistance to canker are somewhat improved, while bush height and the quality and quantity of the fruit crop remain satisfactory. The results give reason to believe that it will eventually be possible to cultivate the highbush blueberry commercially in Finland.

In the evaluation of the F_1 generation and back-crosses, particular attention has been paid to the inheritance of the characters of the parents. In the F_1 generation, the characters show gradation between those of the parents. The back-crosses, as a whole, show a slight shift towards the highbush blueberry.

Index words: *Vaccinium uliginosum,* highbush blueberry, hybridization, inheritance of characters.

Breeding commenced in 1908 and 1909 in the genus *Vaccinium* led to the development of one of the most important cultivated berry plants in the United States, the highbush blueberry. At first breeding was performed with individuals chosen from natural stands, but later it was mainly based on crosses between various species and varieties. As a result, several scores of varieties became available for cultivation (COVILLE 1937, DARROW 1960, DRAPER and SCOTT 1967).

The first highbush blueberry seedlings

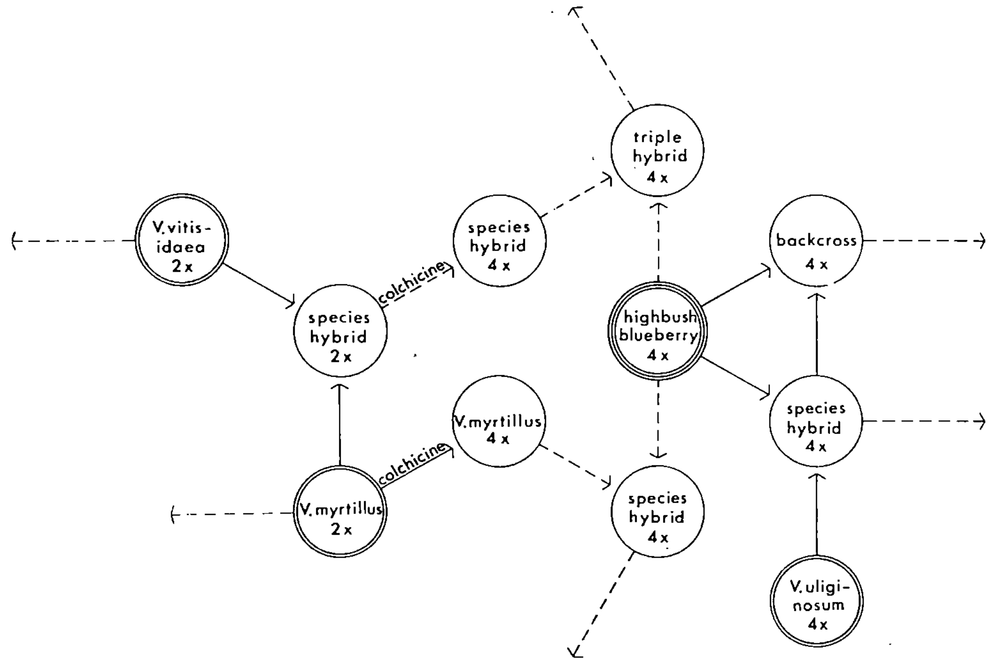

Fig. 1. Schedule for breeding work with the highbush blueberry. The circles represent the original material and different intermediate goals. Arrows with continuous lines show stages already reached and those with broken lines show the programme for the next few years.

imported into Finland from the United States were those obtained by the Institute of Horticulture at Piikkiö in spring 1947 (VAARAMA 1950). Over 30 varieties have been tested so far, and 'June' and 'Rancocas' have clearly proved the most suitable for cultivation (HIIRSALMI and SÄKÖ 1973 a, 1973 b, 1974, 1975). In addition, varieties deserving to be considered for breeding work are 'Atlantic', 'Pemberton' and 'Bluecrop'.

However, none of the varieties could be recommended for commercial cultivation under the climatic conditions prevailing at Finnish latitudes. The characters that may be considered to make the highbush blueberry more suitable for cultivation than the North European *Vaccinium* species are its vigorous bushy growth habit, the high fruit yield partly due to this habit, and the large berries borne in racemose clusters, which permit rapid harvesting. Its chief disadvantages are its rather poor winter hardiness and the frequent infection of the shoots by the blueberry canker caused by the fungus *Fusicoccum putrefaciens* Shear (HÄRDH 1959).

Systematic breeding and selection work has been undertaken at the Institute of Horticulture with a view to reducing these disadvantages, and attempts have been made to cross the highbush blueberry with native *Vaccinium* species (HIIRSALMI 1968, 1969, 1973 a, 1973 b, 1974, cf. also Fig. 1). Successful crosses were achieved with the bog blueberry, *V. uliginosum* L., the only Fennoscandian *Vaccinium* species with the same tetraploid chromosome number, 2n = 48, as the highbush blueberry. The first crosses between the bog blueberry and the highbush blueberry varieties 'Rancocas' and 'Pemberton' were performed in summer 1961 (ROUSI 1963). Although *V. uliginosum* was used as both the seed and pollen parent, viable seeds were obtained only when it was used as the seed parent. Attempts were continued to utilize the gene pool of the bog blueberry for the improvement of the highbush blueberry, and from 1965 onwards the work has included both new primary crosses and successful backcrosses with highbush blueberry varieties. In the back-crosses the highbush blueberry was used as both the seed and pollen parent. The F_1 generation obtained in 1961 and the progeny of the back-crosses made in 1965 have been evaluated, particular attention being paid to the inheritance of characters from the parents.

MATERIAL AND METHODS

The *V. uliginosum* plants used in the crosses were obtained from wild populations at Piikkiö in the vicinity of the Institute of Horticulture, which were transplanted to the experimental field in 1963. The highbush blueberry varieties employed were 'Rancocas', 'Pemberton' and 'Bluecrop', all of which had been set in the experimental field before 1960. 'Rancocas' was originally obtained by crossing the hybrid of the bush-like *V. corymbosum* L. and the dwarf shrub-like *V. lamarckii* Camp with the bushy *V. australe* Small. 'Pemberton' was obtained by back-crossing the hybrid of *V. corymbosum* and *V. australe* with *V. australe*. 'Bluecrop' is the result of four successive crosses, and its gene pool is derived in many different ways from all the three abovementioned *Vaccinium* species.

The members of the F_1 cross and the back-crosses shown in Table 1 were evaluated individually for the following characters: earliness of yield, amount of yield and berry weight in 1970—1974, shape, colour, firmness and flavour of fruit in 1971—1974, readiness for overwintering in October 1971 and 1974, winter hardiness and resistance to blueberry canker in 1967—1974, vigour in 1970—1974, height and diameter of bushes, and thickness and branching of stems in 1972 and 1974, and leaf characters (length, width, length:width, distance from apex to widest part:length and angle of apex) determined on the 1961 crosses and the highbush blueberry varieties in 1967, and on the 1965 crosses in 1970.

The earliness of the yield was determined from the time of harvesting on a five-point scale, in which 1 = very early, 2 = early, 3 = midseason, 4 = late and 5 = very late. A five-point scale was also used for the shape of the fruit, in which 1 = conical, 2 = oval, 3 = rounded, 4 = oblate and 5 = flattened. Ten-point scales were used in evaluating the colour, firmness and flavour of the fruit. On the colour scale 0 = pale grey and 10 = black, on the firmness scale 0 = extremely soft and 10 = extremely firm, and on the flavour scale 0 = extremely poor and 10 = extremely good. Hundred-point scales were used in evaluating readiness for overwintering, winter hardiness, resistance to canker and vigour. On the first scale, 0 = completely unready and 100 = completely ready; on the scale for winter hardiness, 0 = shoot comdead and 100 = shoot completely healthy; on the canker scale, 0 = shoot completely infected and 100 = shoot completely healthy; and on the scale for vigour, 0 = dead and 100 = extremely vigorous. Stem

Table 1. Data on the progeny of the successful crosses made in 1961 and the successful back-crosses made in 1965. Number of individuals set in the trial field and the individuals that have died to date. The progeny of 1961 was planted out in autumn 1963, and that of 1965 partly in autumn 1966 and partly in spring 1967.

Parents	[1]) Code no.	No. of ind. planted	Died	
			1965—1969	1970—1974
V. uliginosum × 'Rancocas'	61007	6	001, 002, 004	003
V. uliginosum × 'Pemberton'	61008	16	003, 016	007
61007002 × 'Rancocas'	65008	7	001, 003, 006	
'Rancocas' × 61007006	65010	6	004	
'Bluecrop' × 61007006	65011	22	005, 008, 010, 012, 014, 022	002
'Pemberton' × 61007001	65016	3	001, 002	
'Rancocas' × 61008002	65017	24	002, 004, 006, 012, 019, 020, 022, 023	001, 003, 008, 011, 013, 014 015, 018

[1]) In the code numbers used for the progeny, the first two digits show the year of the cross, and the three following digits relate to the cross, starting from one in each year. Each member of the progeny planted out in the experimental field is designated by a three-digit number in a series starting from one. This number is added to the end of the code number of the cross, so that each member of the progeny is designated by its own eight-digit code number.

thickness was determined as the average of measurements of the diameter made in the middle of 20 stems. Shoot branching was evaluated on a nine-point scale, in which 1 = no lateral branches and 9 = extremely abundant lateral branches. The values used for the leaf characters were the means of 20 measurements.

The results are mainly summarized in the attached tables and figures. Since the number of individuals in the progeny varied widely and was sometimes very small, the range of variation is given beside the means instead of the mean error.

RESULTS

The detailed investigations of the progeny showed that the individuals of the F_1 cross received genes from each parent, and that their combined effect is manifested in the different characters in rather different ways. In respect of many of the characters the individuals are clearly intermediate between the parents. However, some individuals occasionally resemble one or other of the parents in one or several characters, their values even exceeding those typical of the parent. In the back-crosses the highbush blueberry was both the seed and pollen parent. The variation in the characters of the progeny is remarkably great, and often greater than in the F_1 generation. On average, the progeny of the back-crosses is nearer the highbush blueberry than the bog blueberry

Time of flowering and earliness of yield (Table 2)

At the Institute of Horticulture in Piikkiö, the flowering time of the bog blueberry normally occurs at the beginning of June. In the highbush blueberry, the flowering period is very long, sometimes even six weeks, the peak being reached about two weeks later than in *V. uliginosum.* All the F_1 individuals flower very early, sometimes even earlier than the bog blueberry. The back-crosses largely resemble the highbush blueberry. The time of flowering is clearly reflected in the ripening of the fruit. The F_1 individuals yield their fruit later than the bog blueberry, but on average earlier than the varieties of the highbush blueberry. In most of

Table 2. Mean results of trials with the bog blueberry strains and highbush blueberry varieties, and their crosses and back-crosses in 1970—1974: fruit yield, weight of berries, and earliness of yield determined from time of ripening of fruit. The range of variation is shown for the progeny.

Parents and progeny	Yield g/bush		Wt of 100 berries g		[1]) Time of harvesting 1, 2, 3, 4, 5		No. of ind.
	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	
V. uliginosum	92		55		1,0		
'Rancocas'	824		114		2,6		
'Pemberton'	407		158		3,4		
'Bluecrop'	103		257		4,0		
61007	25	23— 28	70	67— 73	1,6	1,5—1,8	2
61008	37	1—259	65	25—130	2,0	1,0—3,5	13
65008	142	6—272	58	32— 87	2,8	2,6—3,0	4
65010	305	41—497	103	68—129	3,0	2,6—4,0	5
65011	248	82—638	104	59—163	3,2	2,6—4,3	15
65016	154		95		2,8		1
65017	75	1—352	82	69— 98	2,9	1,7—5,0	8

[1]) Earliness of yield: 1 = very early, 2 = early, 3 = midseason, 4 = late, 5 = very late.

Table 3. Mean results of trials with the bog blueberry strain and highbush blueberry varieties, and their crosses and back-crosses in 1971—1974: shape, colour, firmness and flavour of fruit. The range of variation is shown for the progeny.

Parents and progeny	[1]) Shape 1, 2, 3, 4, 5		[2]) Colour 0—10		[3]) Firmness 0—10		[4]) Flavour 0—10		No. of ind.
	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	
V. uliginosum	2,0		1,0		3,9		3,4		
'Rancocas'	4,0		3,5		7,2		7,8		
'Pemberton'	4,0		2,0		7,6		7,3		
'Bluecrop'	5,0		1,0		6,5		6,0		
61007	2,0	1,0—3,0	8,5	7,5—9,5	6,5	5,0—8,0	4,8	4,0—5,5	2
61008	2,3	1,0—4,0	7,9	7,0—9,0	7,2	6,0—9,0	5,0	3,0—7,0	13
65008	2,8	2,5—3,0	6,2	4,0—7,5	5,4	4,0—6,1	4,9	3,5—5,6	3
65010	3,5	3,0—4,0	6,2	4,5—7,5	6,5	5,9—6,9	6,5	5,4—7,2	5
65011	3,4	2,5—4,0	6,4	4,0—8,0	6,0	5,0—7,0	5,8	4,5—7,5	15
65016	2,0		6,0		5,0		6,0		1
65017	3,4	2,0—5,0	5,0	2,5—9,0	6,0	5,0—7,0	5,0	3,0—7,0	5

[1]) Fruit shape: 1 = conical, 2 = oval, 3 = rounded, 4 = oblate, 5 = flattened
[2]) Fruit colour: 0 = pale grey, 10 = black
[3]) Firmness of fruit: 0 = very soft, 10 = very firm
[4]) Flavour of fruit: 0 = very poor, 10 = very good

the individuals of the back-crosses the berries ripen late and unevenly, a disadvantage shared with the highbush blueberry.

Number of flowers and size of yield (Table 2)

The number of flowers varies fairly widely in the F_1 generation, but is always smaller in all the individuals than in the highbush blueberry, although it most often reaches the level of the bog blueberry. When conditions are favourable at the time of flowering, the majority of the flowers develop into berries. On the whole, the yield of the F_1 generation is poor. In the individuals of the back-crosses the number of flowers and size of the yield differ widely. In the most productive individuals the yield almost reaches the level of the best highbush blueberry variety, 'Rancocas'.

Characters of the fruit (Tables 2 and 3)

In the F_1 individuals the berry weight is often almost in the class of the highbush blueberry and is only seldom smaller than in the bog blueberry. In contrast, the berry shape most often resembles that of *V. uliginosum.* Owing to its waxy bloom, the fruit of both the bog blueberry and the highbush blueberry is steel blue in colour. This bloom is absent from the F_1 individuals, so that they are extremely dark. The withered corolla remains attached to the ripened fruit in some of the F_1 individuals, as is regularly the case in the bog blueberry. Although the fruit of the F_1 generation is as firm as that of the highbush blueberry varieties when fresh, it is not suitable for deep freezing. Its taste is also inferior to that of the highbush blueberry, having something of the characteristically bitter flavour of the bog blueberry. In the back-crosses, the berry weight varies widely, ranging from that of the highbush blueberry to that of the bog blueberry. The berries are rounded, almost spherical. The colour of the fruit depends on the occurrence of the waxy bloom, grading from steel-blue to almost black. With a few exceptions, the withered corolla does not remain attached to the berries of the back-crosses. On average, the fruit is less firm than in the F_1 generation, but many individuals have berries that are suitable for deep-freezing. Perhaps the most pronounced difference found between the individuals of the back-crosses is that evident in the flavour of their berries, a character which is extremely difficult to describe in concrete terms. It varies from good to poor, from sweet to sour, and from strong to weak, sometimes resembling that of the highbush blueberry and sometimes that of the bog blueberry.

Readiness for wintering and winter hardiness
(Table 4)

The shoots of *V. uliginosum* become ready for overwintering in good time before the advent of winter, so that its winter hardiness is much better than that of the highbush blueberry varieties. The readiness for overwintering is clearly higher in the F_1 generation than in the back-crosses, but the same trend is not found in winter hardiness.

Resistance to blueberry canker
(Table 4)

All the highbush blueberry varieties are very susceptible to blueberry canker, but the bog blueberry is never infected. The canker is found on all the F_1 individuals, but only on a few branches. The canker occurs commonly on the back-crosses, although their resistance is much greater than in the highbush blueberry varieties.

Vigour
(Table 4)

The differences in this character among the crosses and back-crosses do not show any consistent trend. Many weak individuals did occur, some of which died before 1970 (Table 1), and if they had been included in the evaluation, the progeny would have proved weaker than the parents in several cases. On the other hand, mortality is also high among the seedlings of many of the highbush blueberry varieties.

Bush size and shape
(Figs. 2 and 4)

The size and shape of the bushes was determined by measuring their height and diameter,

Table 4. Mean results of trials with the bog blueberry strain and highbush blueberry varieties, and their crosses and back-crosses: winter hardiness and resistance to canker in 1967—1974, vigour in 1970—1974, and readiness for wintering in 1971 and 1974. The range of variation is given for the progeny.

Parents and progeny	[1]) Readiness for wintering 0—100		[2]) Winter hardiness 0—100		[3]) Resistance to canker 0—100		[4]) Vigour 0—100		No. of ind.
	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	
V. uliginosum	98		91		100		78		
'Rancocas'	55		85		58		87		
'Pemberton'	65		76		34		80		
'Bluecrop'	35		57		38		75		
61007	93	90—95	80	75—84	96	92—99	82	79— 84	2
61008	92	80—100	67	40—87	94	92—96	77	56— 95	13
65008	84	65—95	75	48—87	69	61—74	72	34— 88	4
65010	88	75—95	84	78—88	75	71—76	80	63— 93	5
65011	75	45—95	79	47—96	71	58—82	78	46—100	15
65016	85		79		69		74		1
65017	71	55—90	72	45—91	71	58—94	70	33— 95	8

[1]) Readiness for wintering: 0 = completely unready, 100 = completely ready
[2]) Winter hardiness: 0 = shoot completely dead, 100 = shoot completely healthy
[3]) Resistance to canker: 0 = shoot completely infected, 100 = shoot completely healthy
[4]) Vigour: 0 = dead, 100 = extremely vigorous

assessing the amount of branching and measuring the thickness of the stems. All the highbush blueberry varieties have remarkably large bushes, in which the erect thickish stems have few branches (mean diameters of stems: 'Rancocas' 43 mm, 'Pemberton' 37 mm, and 'Bluecrop' 46 mm). The bog blueberry is a dwarf shrub, whose thin abundantly branching stems have a trailing habit (mean diameter of stem 13 mm). The F_1 individuals are also abundantly branched and somewhat trailing. In contrast, the individuals of the back-crosses almost all have an erect growth habit, but their thinnish stems are clearly more abundantly branched than those of the highbush blueberry.

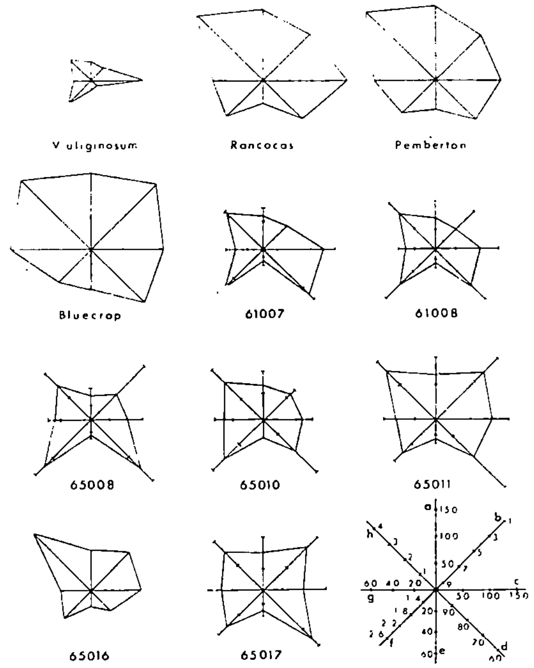

Fig. 2. Polygons illustrating four shoots and four leaf characters of the bog blueberry strain and highbush blueberry varieties, and their crosses and back-crosses. The scheme used in drawing the polygons is shown at bottom right. The characters are: a = bush height (cm), b = branching (1—9), c = bush diameter (cm), d = angle of leaf apex (degrees), e = leaf width (mm), f = leaf length: leaf width, g = leaf length (mm), h = stem thickness (mm).

Leaf characters
(Fig. 2)

The leaves of *V. uliginosum* are small and fairly wide with a blunt apex, whereas the leaves of the highbush blueberry varieties are remarkable large. The leaf characters of the crosses and back-crosses do not differ greatly from each other, but generally deviate from those of the parents.

DISCUSSION

The crosses performed at the Institute of Horticulture between the highbush blueberry and *V. uliginosum* gave rise to progeny whose characters, most of which can be readily quantified, show gradation between those of the parents. The position in relation to the parents of the whole F_1 generation and the back-crosses, and of separate members of the progeny can be conveniently illustrated by polygons based on four shoot and four leaf characters (Fig. 2), by hybrid indices calculated from five leaf characters (Fig. 3) and by a diagram presenting four shoot characters (Fig. 4).

F_1 seedlings from crosses between the bog blueberry and the highbush blueberry are larger and more vigorous than seedlings of the parent species at the same age (Rousi 1963), clearly displaying hybrid vigour. However, this vigour decreases in many of the individuals before they become fully grown, and some of them die. In addition, in many of the F_1 individuals the leaves show a certain degree of etiolation. Meiosis was found to be unexpectedly regular in the F_1 individuals (Rousi 1966, 1967), but in spite of this many berries occur in which there are only a few seeds or no seeds at all. The germination of the seeds is also rather poor. The F_1 individuals of the cross between the bog blueberry and the highbush blueberry clearly possess the unfavourable gene combinations typical of crosses between two widely separate species, which in time can cause a great variety

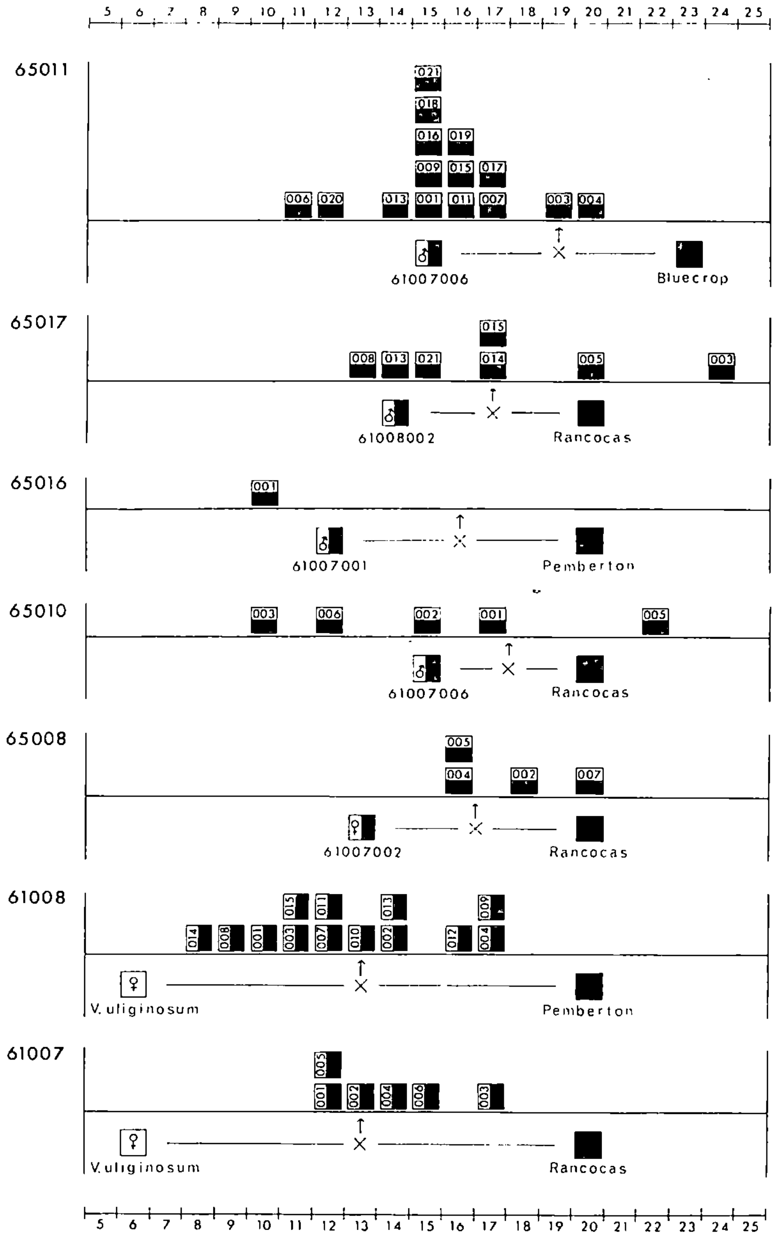

Fig. 3. Hybrid indices for the bog blueberry strain, highbush blueberry varieties, and crosses and back-crosses, calculated from five leaf characters (length, width, length: width, distance from apex to widest part: length, angle of apex). Each character was scored according to a scale that ran from 1 to 5, and was obtained by dividing the range of the total values for the character into five equal parts. The lowest possible index is thus 5 and the highest 25. The progeny of each cross and back-cross was first treated separately with its parents and then related to a common scale based on the hybrid indices of the cross *V. uliginosum* × 'Rancocas' (61007).

Fig. 4 (a—e). Diagrams illustrating four shoot characters. Black circles represent the bog blueberry strain, white circles the highbush blueberry varieties, circles with the left half black represent crosses, circles with the lower half black backcrosses. The vertical axis shows bush height (cm), the horizontal axis bush diameter (cm). The size of the circles is in proportion to the thickness of the stem, and the number of short lines projecting from them shows the degree of branching.

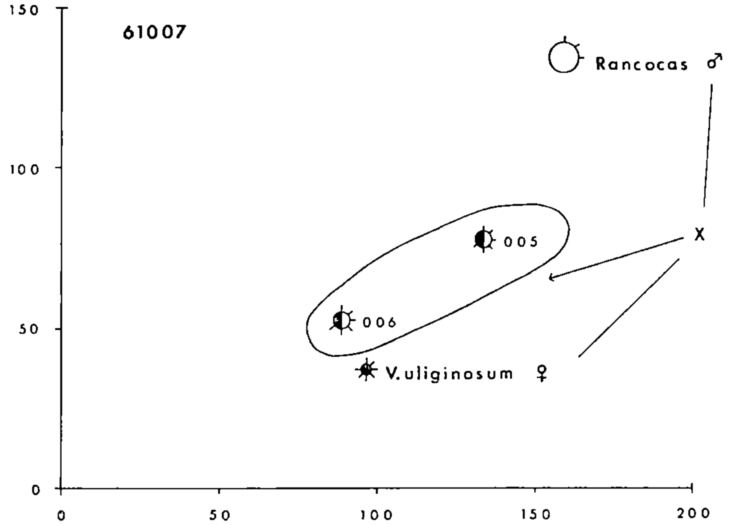

Fig. 4 a. Cross between *V. uliginosum* and 'Rancocas' (61007).

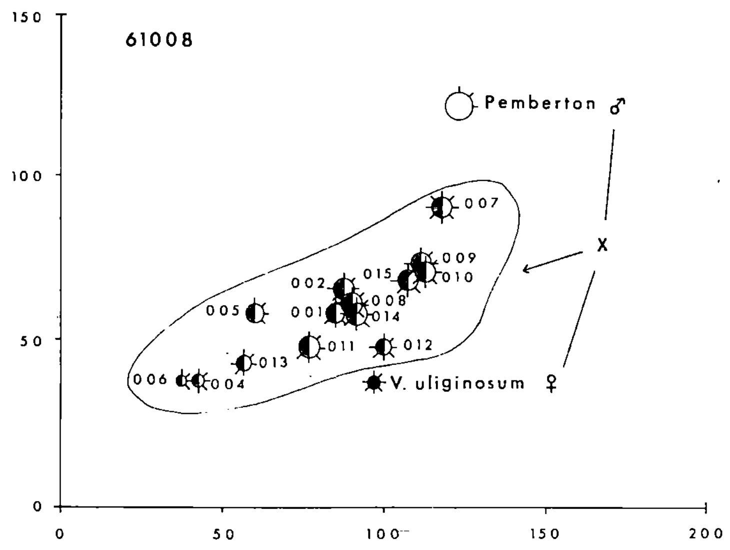

Fig. 4 b. Cross between *V. uliginosum* and 'Pemberton' (61008).

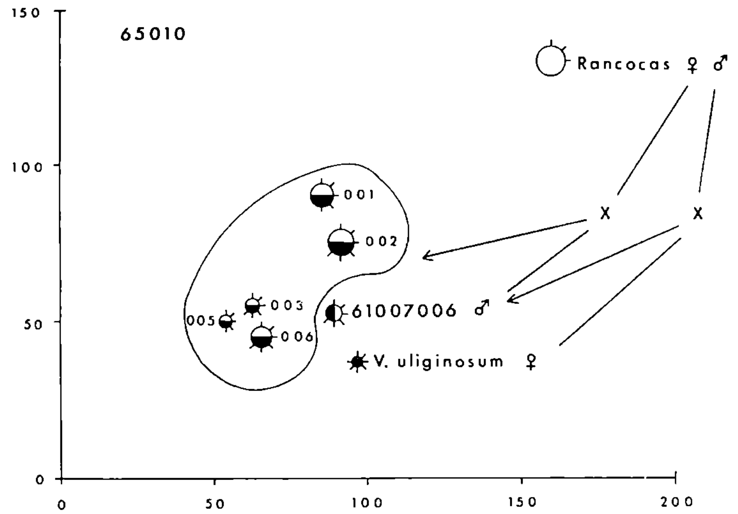

Fig. 4 c. Back-cross of hybrid of *V. uliginosum* and 'Rancocas' (61007006) with 'Rancocas' (65010).

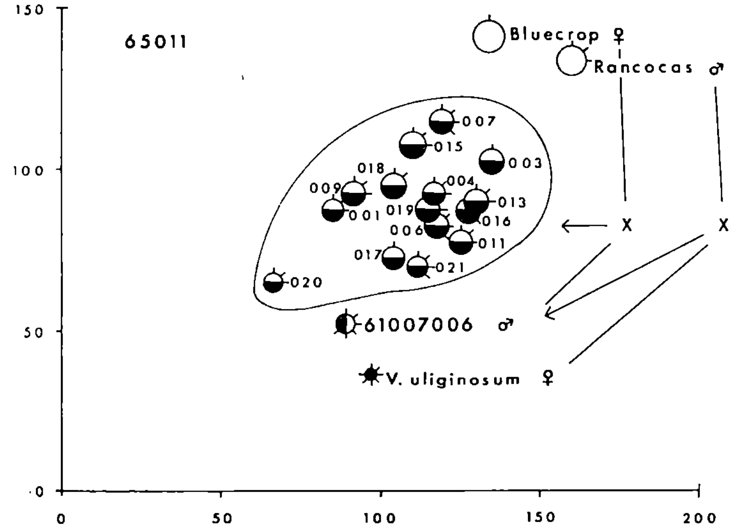

Fig. 4 d. Back-cross of hybrid of *V. uliginosum* and 'Rancocas' (61007006) with 'Bluecrop' (65011).

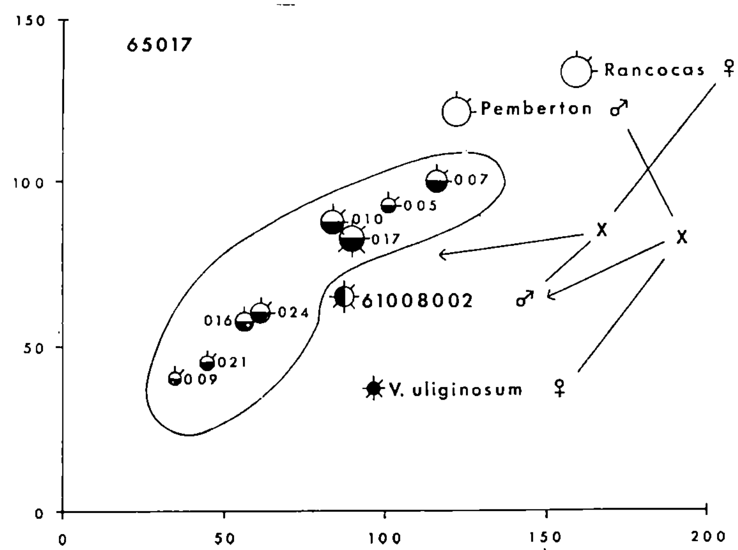

Fig. 4 e. Back-cross of hybrid of *V. uliginosum* and 'Pemberton' (61008002) with 'Rancocas' (65017).

Table 5. Mean results of trials with selected individuals from back-crosses of the bog blueberry and the highbush blueberry: fruit yield, weight of berries and vigour in 1970—1974, winter hardiness and resistance to canker in 1967—1974 and bush height in 1972 and 1974.

Code no.	Yield g/bush	Wt of 100 berries g	[1]) Winter hardiness 0—100	[2]) Resistance to canker 0—100	[3]) Vigour 0—100	Bush height cm
65010002	497	114	80	76	93	74
65011011	464	156	87	75	88	77
65011016	638	119	96	83	100	79
65011019	476	151	84	67	82	79
65011021	492	110	90	82	82	65
65017017	352	69	78	76	77	78

[1]) Winter hardiness: 0 = shoot completely dead, 100 = shoot completely healthy
[2]) Resistance to canker: 0 = shoot completely infected, 100 = shoot completely healthy
[3]) Vigour: 0 = dead, 100 = extremely vigorous

of disturbances. This is evident in weakened vigour and, for example, a consequent decrease in winter hardiness and fruit yield. The F_1 generation thus failed to provide any individual that was suitable for commercial cultivation.

When the F_1 individuals are back-crossed with the highbush blueberry varieties, the unfavourable gene combinations are, at least partly, eliminated. A number of fairly promising individuals have been obtained, in which winter hardiness and resistance to canker are somewhat improved, while bush height and the quality and quantity of the fruit crop remain satisfactory (Table 5). More plants of the back-cross progeny can be set per unit area than the large individuals of the highbush blueberry, so that in commercial cultivation their fruit yield will probably not be much smaller than that of the highbush varieties. The hybrids with the most favourable gene combinations thus give reason to believe that it will eventually be possible to establish commercial plantings in Finland with blueberry varieties whose adaptation to conditions at northern latitudes has been improved by the gene pool of the bog blueberry.

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SELOSTUS

Juolukan ja pensasmustikan ominaisuuksien periytyminen lajiristeytymiin

HEIMO HIIRSALMI

Maatalouden tutkimuskeskus

Pensasmustikan koeviljelyssä Suomessa saadut kokemukset eivät ole olleet kyllin hyviä, jotta olisi päästy käytännön sovellutuksiin. Kaikki lajikkeet ovat alttiita talvivaurioille ja *Fusicoccum putrefaciens* Shear -sienen aiheuttamalle mustikkasyöpätaudille.

Paremmin pohjoisiin ilmasto-oloihin sopeutuvien pensasmustikkalajikkeiden kehittämiseksi Puutarhantutkimuslaitoksella Piikkiössä suoritetaan jalostustoimintaa pyrkimällä risteyttämään kotimaisia *Vaccinium*-lajeja pensasmustikkalajikkeiden kanssa. Vain juolukkaa, *V. uliginosum* L. on toistaiseksi onnistuneesti käytetty risteytyksiin.

Juolukan ja pensasmustikan F_1-risteytysjälkeläistöissä on aivan ilmeisesti sellaisia kahden toisilleen etäisen lajin risteytymälle ominaisia epäedullisia geeniyhdistelmiä, jotka aiheuttavat ajan mittaan häiriöitä. Ne ilmenevät elinvoiman heikkenemisenä ja sen myötä mm. talvenkestävyyden ja sadon määrän laskuna. F_1-risteytysjälkeläistöistä ei siis ole voitu löytää yhtään yksilöä, jolla olisi merkitystä käytännön marjanviljelylle.

Takaisinristeyttämällä F_1-risteytymäyksilöitä pensasmustikkalajikkeiden kanssa epäedulliset geeniyhdistelmät ovat ainakin osittain hajonneet. Näin on syntynyt joukko varsin lupaavia yksilöitä, joissa pensasmustikan talven- ja mustikkasyövänkestävyyttä on kyetty jossakin määrin lisäämään. Yksilökorkeus, sadon määrä ja laatu ovat säilyneet silti tyydyttävinä. Tulokset ovat antaneet perusteltua uskoa siihen, että käytännön pensasmustikan viljelyyn voidaan Suomessakin päästä.

F_1-risteytys- ja takaisinristeytysjälkeläistöjen arvostelun yhteydessä on tutkittu erityisesti ominaisuuksien periytymistä. Vanhempien ominaisuudet, joista useimmat ovat selvästi kvantitatiivisia, esiintyvät F_1-risteytysjälkeläistöissä eriasteisina välimuotoina. Takaisinristeytysjälkeläistöissä on tapahtunut kokonaisuudessaan vähäistä siirtymistä pensasmustikan suuntaan.

ANNALES AGRICULTURAE FENNIAE, VOL. 16:19—26 (1977)
Seria HORTICULTURA N. 32 — Sarja PUUTARHAVILJELY n:o 32

STUDIES ON QUALITY OF VEGETABLES AND STRAWBERRIES AT DIFFERENT LATITUDES IN FINLAND

KIRSTI HÅRDH and J. E. HÅRDH

HÅRDH, K. & HÅRDH, J. E. 1977. **Studies on quality of vegetables and strawberries at different latitudes in Finland.** Ann. Agric. Fenn. 16:19—26. (Univ. Helsinki, Dept. Hortic. SF-00710 Helsinki 71, Finland.)

In studying the quality of vegetables and strawberries from different latitudes in Finland, it was shown clearly that differences do occur in some vegetables and strawberries. Sugar and dry matter content in carrot, beet root, swede and strawberry was higher in the north than in southern localities. Carotene content in carrot and parsley was lower in the north than in the south, and in tomato and sweet pepper depending on the greenhouse temperature. The often high temperature in greenhouses in Viikki decreased the carotene content in sweet pepper. The red and yellow colours in strawberry, tomato and beet root, and the green in spinach and lettuce were more intense in the north than in the south. The yellow in carrot and the red and yellow in sweet pepper increase at high temperatures, so that these colours are more intense in the southernmost localities.

Index words: quality, vegetables, strawberry.

It has been shown earlier that climatic and ecological factors at different latitudes in Finland may have a striking effect on the ascorbic acid, carotene and aroma contents of some vegetables (HÅRDH 1975, HÅRDH et al. 1972, 1977). The main factors influencing quality may be day length, the amount and quality of radiation and temperature. It was shown that total radiation in the north is less than in southern Finland and that the relation of blue to red radiation in the growth period is from 1,8 to 2,1 in the north whereas in the southern parts of the country it is from 1,2 to 1,6. The total mean temperature above + 5°C during growth periods in 1971—73 was 778° in the north, and 1374° in South Finland. The cool night temperature especially may increase net assimilation and the sugar and ascorbic acid contents of the plants (HÅRDH 1975). The aim of further experiments was to examine the carotene, dry matter, sugar content and colour of vegetables and strawberries from different parts of the country.

Experimental sites were

Viikki 60°11' N
Ilomantsi 62°40' N
Rovaniemi 66°32' N
Muddusniemi 69°04' N

Mean temperatures for these localities in 1971—74 are shown in Table 1. It can be seen that the summer of 1972 was exceptionally warm throughout the country. In 1971, 1973 and 1974 temperature differences at the experimental sites were significant.

Table 1. Mean and normal monthly temperatures in 1971—74.

	Outdoors																			
	Viikki					Ilomantsi					Rovaniemi					Muddusniemi				
	V	VI	VII	VIII	IX	V	VI	VII	VIII	IX	V	VI	VII	VIII	IX	V	VI	VII	VIII	IX
1971	10,1	14,2	17,0	15,6	9,1	6,8	12,3	15,4	13,9	6,7	4,5	12,4	14,2	12,5	5,4	2,8	9,1	12,2	11,0	4,8
1972	9,1	16,5	20,1	16,8	10,5	7,1	15,9	19,5	16,2	8,3	4,6	14,9	17,9	13,2	7,0	2,9	14,0	16,8	12,9	5,6
1973	13,4	15,4	18,6	13,8	9,3	—	14,0	17,1	12,3	—	—	13,8	18,8	17,2	6,0	10,3	12,4	16,9	9,5	4,8
1974	7,2	14,7	15,9	14,8	12,7	4,4	14,6	17,0	13,8	10,9	4,4	13,9	15,5	13,0	7,3	3,5	12,3	15,4	12,0	9,0
Norm.	8,4	14,1	17,2	15,6	10,5	7,2	13,1	16,0	14,1	8,3	5,7	12,0	15,1	13,0	7,3	3,6	9,9	13,8	11,6	6,4

	In greenhouse														
	Viikki					Rovaniemi					Muddusniemi				
	V	VI	VII	VIII	IX	V	VI	VII	VIII	IX	V	VI	VII	VIII	X
1971	19,8	19,4	21,5	20,8	19,0	—	—	—	—	—	18,5	17,1	18,5	16,9	15,1
1972	19,6	21,8	23,6	21,3	19,9	17,8	19,8	20,3	18,1	16,7	8,3	18,7	19,0	16,5	10,6
1973	21,6	22,2	23,2	20,9	19,4	19,5	19,7	20,9	17,9	19,3	15,5	18,0	22,3	15,0	18,1
Mean	20,3	21,1	22,8	21,0	19,4	18,7	19,8	20,6	18,0	18,0	14,1	17,9	19,9	16,1	14,6

MATERIAL AND METHODS

As mentioned before (HÅRDH et al. 1977), dry matter was determined after 18 hours drying at 105°C. Sugar content was determined by Schoorl's method, using Fehling's solution.

Carotene was extracted with a mixture of petroleum ether and acetone (3:1 and 6:4). The carotenes were separated from eluate by means of a column chromatograph (KNOWLES et al. 1972).

Colour and its intensity were determined from fresh samples using the Hunterlab Color Difference Meter, and the a (+a red and —a green) and b (+b yellow and — b blue) scale. The lightness was counted using data from 0 to 100 (0 = dark, 100 = white).

The growth substrate was ST 400 A3 peat of the same origin throughout. In addition, the influence of Soinlahti bark-humus mixed with mineral soil in quantities of 5 m^3 and 10 m^3 per 100 m^2 was tested outdoors. Fertilization, irrigation and handling of plants and samples were equal in all experiments. The samples were sent by air to the Department of Horticulture at Viikki, where they were analyzed or deep-frozen not more than six hours after being taken.

RESULTS

In the greenhouse, the dry matter and sugar content of tomato may be slightly higher in the north than in southern areas, the differences in sweet pepper, however, were not significant. In root crops, swedes and beetroot, in the north, greater quantities of dry matter and total sugar were clearly visible, expressed as per cent of fresh weight; in carrot the sugar content was dependent on the development stage and size at the time of harvest. In the northernmost experiments, the carrots and beetroots were not fully developed when harvested, and the higher sugar content may have been due to this (Tables 2 and 3).

The dry matter and sugar content of strawberry (Table 4) was significantly high in Ilomantsi, a locality with a continental climate and the greatest number of sunshine hours during the growing season.

Carotene contents were expressed as amounts of $\alpha + \beta$ carotenes and of lycopene and xanthophyll. In outdoor vegetables, carrot and parsley, the carotene quantities were less in the north due to the lower temperatures (Table 5). As SCHUPHAN (1969) stated, carotene content in the plants is improved by high temperatures; however, in the greenhouse the temperature may sometimes be too high for β carotene

Table 2. Dry matter and total sugar contents of vegetables in 1971—73.

Tomato — cv 'Minerva F_1WW', greenhouse, substrate ST 400 A3 peat.

	1971 Dry matter %	1971 Sugar %	1972 Dry matter %	1972 Sugar %	1973 Dry matter %	1973 Sugar %	Mean Dry matter %	Mean Sugar %
Viikki	5,0	1,4	6,1	2,4	5,2	1,9	5,4	1,9
Rovaniemi	5,9	2,3	5,9	2,9	5,7	2,0	5,8	2,4
Muddusniemi ...	5,9	2,0	4,8	2,5	4,9	2,5	5,2	2,3

Table 2. Continuation.

Sweet pepper cv 'Pedro F_1 Hg', greenhouse, substrate ST 400 A3 peat

	1971		1972		1973		Mean	
	Dry matter %	Sugar %	Dry matter %	Sugar %	Dry matter %	Sugar %	Dry matter %	Sugar %
Viikki	9,7	3,7	9,7	5,3	11,2	6,3	10,2	5,1
Rovaniemi	9,3	4,1	9,5	4,1	10,9	5,9	9,9	4,7
Muddusniemi ...	8,5	3,8	9,4	4,6	10,0	4,8	9,3	4,4

Carrot cv 'Fancy OE', fine sand + 5 $m^3/100\ m^2$ bark humus

	1971		1972		1973		Mean	
	Dry matter %	Sugar %	Dry matter %	Sugar %	Dry matter %	Sugar %	Dry matter %	Sugar %
Viikki	10,1	3,5	11,8	3,3	10,8	5,6	10,9	4,1
Ilomantsi	11,3	5,3	10,3	5,1	10,9	5,2	10,8	5,2
Rovaniemi	11,0	3,6	10,2	5,0	10,7	5,1	10,6	4,6
Muddusniemi ...	10,6	2,1	12,2	5,9	11,9	5,6	11,6	4,5

Table 3. Dry matter and total sugar contents of vegetables in 1972—73.

Red beet cv 'Boltardy', fine sand + 5 $m^3/100\ m^2$ bark humus

	1972			1973			Mean		
	Dry matter %	Sugar %	Refr.	Dry matter %	Sugar %	Refr.	Dry matter %	Sugar %	Refr.
Viikki	12,0	6,6	10,3	13,7	8,9	13,0	12,9	7,8	11,7
Ilomantsi	13,2	6,4	11,4	15,3	8,5	13,5	14,3	7,5	14,4
Rovaniemi	15,1	7,3	13,8	15,7	8,6	14,4	15,4	8,0	14,1
Muddusniemi	17,0	9,8	15,5	16,6	10,2	14,0	16,8	10,0	14,8

Swedes cv 'Östgöta WW', fine sand + 5 $m^3/100\ m^2$ bark humus

	1972	1973			Mean
	Dry matter %	Dry matter %	Sugar %	Refr.	Dry matter %
Viikki	9,7	8,9	4,9	7,2	9,3
Ilomantsi	8,1	9,8	5,9	8,7	9,0
Rovaniemi	11,2	10,9	5,5	8,0	11,1
Muddusniemi	10,7	11,3	7,1	10,5	11,0

Potato cv 'Bintje', fine sand + 5 $m^3/100\ m^2$ barknhumus

	Dry matter in %		
	1972 late harvest	1973 early harvest	1973 late harvest
Viikki	19,8	18,9	19,1
Ilomantsi	21,9	16,7	17,9
Rovaniemi	15,4	15,9	18,1
Muddusniemi	18,7	16,8	18,4

Table 4. Dry matter and total sugar contents of strawberry in 1973–74.

cv 'Senga Sengana', fine sand + 5 $m^3/100\ m^2$ bark humus

	1973			1974	
	Dry matter %	Sugar %	Refr.	Sugar %	Refr.
Viikki	8,6	4,1	7,5	4,9	8,4
Ilomantsi	14,3	6,5	12,1	6,2	8,7
Rovaniemi	9,9	5,4	9,0	–	–
Muddusniemi	11,3	7,4	–	–	–

synthesis. This fact clearly influences the results in tomato and sweet pepper, where carotene contents in the warm summer of 1972 were higher in the northern experiments. Optimum temperature for β carotene synthesis is probably from 10° to 15°C.

C o l o u r i n t e n s i t y. The intensity of the red colour (+a) in tomato was higher in Muddusniemi than in Viikki as was the yellow colour (+b) (Table 6). Sweet pepper, on the other hand, favours warmth and the degree of pigments +a and +b are, thus, lower in the

Table 5. Carotene contents of vegetables in 1970–73.

Carrot — cv 'Fancy OE', fine sand + 5 $m^3/100\ m^2$ bark humus

Carotene ($\alpha + \beta$) mg/100 g

	1970	1971	1972	1973	Mean	Mean weight of root
Viikki	5,33	8,96	4,55	9,25	7,02	110
Ilomantsi	2,05	4,07	2,93	5,79	3,71	57
Rovaniemi	–	4,00	3,15	7,61	4,92	42
Muddusniemi	2,37	3,62	4,19	3,97	3,54	18

Parsley — cv 'Bravour 325 OE', substrate ST 400 A3 peat

Carotene ($\alpha + \beta$) mg/100 g

	Glasshouse	Plastic house	Outdoors
Viikki	2,41	5,49	2,87
Ilomantsi	–	–	3,16
Rovaniemi	–	2,54	1,67
Muddusniemi	2,12	2,29	1,79

Tomato — cv 'Minerva F_1WW', greenhouse, substrate ST 400 A3 peat

Carotene mg/100 g

	1971		1972		1973		Mean	
	$\alpha + \beta$	lycop.	$\alpha + \beta$	lycop.	$\alpha + \beta$	lycop.	$\alpha + \beta$	lycop.
Viikki	0,44	2,6	0,49	2,1	0,45	1,9	0,46	2,2
Rovaniemi	0,49	1,8	0,99	4,1	0,45	1,8	0,64	2,6
Muddusniemi	0,39	1,3	0,79	3,4	0,27	2,5	0,48	2,4

Sweet pepper — cv 'Pedro F_1Hg', greenhouse, substrate ST 400 A3 peat

Carotene mg/100 g

	1971	1972		1973		Mean	
	($\alpha + \beta$)	($\alpha + \beta$)	xantoph.	($\alpha + \beta$)	xantoph.	($\alpha + \beta$)	xantoph.
Viikki	1,48	0,49	9,3	1,98	13,8	1,32	11,5
Rovaniemi	1,29	1,63	13,9	3,46	19,8	2,13	16,8
Muddusniemi	1,58	1,58	10,9	1,98	8,8	1,71	9,8

Table 6. Lightness and color of tomato and sweet pepper at different localities in 1971—73. Glasshouse on peat substrate.

Lightness and color									
Tomato	cv 'Minerva'				Sweet pepper	cv 'Pedro'			
	L	+a	+b	a/b		L	+a	+b	a/b
1972					1971				
Viikki	35,8	32,2	15,6	2,07	Viikki	33,1	26,7	10,7	2,49
Rovaniemi	36,3	29,2	16,8	1,74	Rovaniemi	32,5	28,4	11,3	2,51
Muddusniemi	38,6	35,7	17,7	2,02	Muddusniemi	32,1	29,5	11,4	2,59
1973					1972				
Viikki	29,8	29,6	14,7	2,01	Viikki	28,1	35,4	12,7	2,79
Rovaniemi	30,5	32,8	15,9	2,07	Rovaniemi	29,4	23,9	8,8	2,72
Muddusniemi	31,9	34,0	17,0	1,99	Muddusniemi	30,3	31,8	12,3	2,59
Mean					1973				
Viikki	32,8	30,9	15,2	2,03	Viikki	25,3	42,3	13,2	3,21
Rovaniemi	33,4	31,0	16,4	1,89	Rovaniemi	25,1	35,7	10,9	3,28
Muddusniemi	35,3	34,9	17,4	2,01	Muddusniemi	24,8	40,6	12,7	3,19
					Mean				
					Viikki	28,8	34,8	12,2	2,85
					Rovaniemi	29,0	29,3	10,3	2,85
					Muddusniemi	29,1	33,9	12,1	2,80

Table 7. Lightness and color of carrots and red beet at different localities in 1972—73, on sandy soil + bark humus 5 $m^3/100\ m^2$.

Lightness and color									
Carrot	cv 'Fancy OE'				Red beet	cv 'Boltardy SG'			
	L	+a	+b	a/b		L	+a	+b	a/b
1972					1972				
Viikki	54,9	39,7	31,0	1,28	Viikki	20,4	21,9	5,6	3,91
Ilomantsi	52,7	37,2	29,7	1,25	Ilomantsi	20,6	24,0	5,9	4,07
Rovaniemi	52,6	37,3	30,0	1,24	Rovaniemi	22,1	28,8	7,0	4,12
Muddusniemi	51,1	33,0	27,5	1,20	Muddusniemi	19,2	18,4	4,4	4,18
1973					1973				
Viikki	51,6	37,6	28,8	1,31	Viikki	19,4	21,8	3,7	5,93
Ilomantsi	51,5	31,4	28,2	1,12	Ilomantsi	18,7	19,0	2,9	6,49
Rovaniemi	49,6	32,8	27,4	1,35	Rovaniemi	19,6	22,7	3,7	6,17
Muddusniemi	59,9	27,7	30,6	0,91	Muddusniemi	18,1	16,6	2,2	7,42
Mean					Mean				
Viikki	53,3	38,7	29,9	1,29	Viikki	19,9	21,9	4,7	4,66
Ilomantsi	52,1	34,3	28,9	1,19	Ilomantsi	19,7	21,5	4,4	4,89
Rovaniemi	51,1	35,1	28,7	1,22	Rovaniemi	20,9	25,8	5,4	4,78
Muddusniemi	55,5	30,4	29,1	1,05	Muddusniemi	18,7	17,5	3,3	5,30

Table 8. Lightness and color of spinach and lettuce at different localities in 1973 outdoors on peat substrate.

Spinach	cv 'Medania LD'			
	L	—a	+b	a/b
1973				
Viikki	35,5	9,6	12,1	0,79
Ilomantsi	35,1	7,8	12,7	0,62
Rovaniemi	38,9	10,6	14,7	0,72
Muddusniemi	39,3	11,0	14,9	0,74

Lettuce	cv 'Market Favourite'			
	L	—a	+b	a/b
1973				
Viikki	46,0	11,9	18,5	0,64
Ilomantsi	47,0	11,1	18,7	0,59
Rovaniemi	49,8	11,5	21,3	0,54
Muddusniemi	48,7	12,2	20,0	0,61

Table 9. Lightness and color of strawberry at different localities in 1973, on sandy soil + bark humus 5 $m^3/100$ m^2, cv 'Senga Sengana'.

	L	+a	+b	a/b
1973				
Viikki	24,9	21,6	7,3	2,96
Ilomantsi	26,8	24,9	8,8	2,83
Rovaniemi	29,2	24,9	9,5	2,62
Muddusniemi	24,0	30,3	9,4	3,22

north. In Rovaniemi colour intensities for sweet pepper were lowest due to the poor lighting in the greenhouse.

The yellow in carrot is due to carotenes who favour high temperatures. In addition, as stated before, the carrots in the north were not fully developed at the time of harvest. The red and yellow colours in beetroot were most intensive in Rovaniemi; in Muddusniemi, at the northernmost locality, the total amount of these colours was lowest, the ratio of red to yellow colour being highest (Table 7). Spinach and lettuce grown in the north were greener (—a data) than in the south, the yellow colour (+b) being more intense, too (Table 8). The colour differences, both red and yellow, in strawberries were striking. In the north the degree of red colouring was higher, as was the degree of yellow (Table 9).

DISCUSSION

From the results shown above and already published, it is seen that the climatic factors at latitudes 67° and 69° have a favourable effect on the quality of some vegetables compared to latitude 60°. The causes of the quality differences shown by the analyses are often difficult to explain. The short night allows the crops less time to transform the assimilation products, primarily sugar, into a form better adapted for storing which, in turn, gives greater amounts of dry matter. Thus, the reason for the high sugar content in vegetables grown in the north is, perhaps, that they do not get a dark period sufficiently long for sugar transformation to take place during the very intensive assimilation period.

Synthesis of the carotenes depends mainly on temperature, and many workers have shown a connection between high carotene content and high temperatures. In the greenhouse, however, the temperature may sometimes be too high for favourable β-carotene formation.

Thus the colour of the greenhouse tomato is often less intense in the south than in northern areas, where the greenhouse temperatures are lower (Table 1). Outdoor temperatures in the north are low and less favourable for carotene synthesis, and the carrots have less yellow colour than in southern Finland. In addition, the carrots have not reached full development in the north when they are harvested. The green colour of spinach and lettuce is more intensive in the north (Table 8). This is apparently due to the longer days and the light being more rich in blue radiation than in the south, factors which favour chlorophyll formation.

There may even be other differences between vegatables grown at different latitudes: protein content and quality and fibre content. More research is, however, needed to elucidate these properties and the causes of the differences.

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SELOSTUS

Vihannesten ja mansikan laatu eri leveysasteilla Suomessa

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Yliopiston puutarhatieteen laitoksella selvitettiin vuosina 1969—74 vihannesten ja marjojen "sisäistä" laatua eri leveysasteilla Suomessa. Aikaisemmin julkaistujen tulosten lisäksi selostetaan nyt vuosina 1971—74 suoritettujen kokeiden tuloksia tomaatilla, paprikalla, porkkanalla, punajuurikkaalla, lantulla, perunalla, pinaatilla, salaatilla, persiljalla ja mansikalla.

Kasvualusta, lannoitus ja hoitotoimenpiteet olivat samalla kasvilla eri koepaikoissa samat, ja näytteet tutkittiin puutarhatieteen laitoksella Viikissä. Kuiva-aine- ja sokeripitoisuudet tomaatilla, porkkanalla, punajuurikkaalla, lantulla ja mansikalla olivat pohjoisessa Muddusniemessä ja Rovaniemellä selvästi korkeammat kuin Etelä-Suomessa Viikissä. Sen sijaan paprikalla ja perunalla ei selvää eroa eri leveysasteilla ollut.

Karoteenipitoisuudet olivat etelässä suuremmat, lukuunottamatta kasvihuonetomaattia ja paprikaa, joilla pitoisuudet olivat pohjoisessa korkeammat. Tämä saattoi johtua siitä, että β-karoteenin ja lykopeenin muodostumiselle olivat lämpötilat kasvihuoneessa Viikissä optimia korkeammat. Optimilämpötilat ovat noin 10—15°C.

Tomaatin värittyminen oli Muddusniemessä voimakkainta. Lämpötilat olivat siellä lykopeenin ja karoteenin muodostumiselle edullisemmat ja alhaisemmat kuin Viikin kasvihuoneissa. Paprikalla, joka on lämpöä vaativa kasvi, erot olivat epäselvät, samoin porkkanalla, jolla väri johtuu yksinomaan karoteenista. Punajuurikas oli Rovaniemellä voimakkaimmin värittynyttä. Sen sijaan Muddusniemessä siinä oli sekä punaista (+a) että keltaista (+b) väriainetta vähemmän kuin Viikissä, mikä johtui punajuurikkaan keskeneräisestä kehitysvaiheesta korjattaessa. Pinaatin ja salaatin vihreän (—a) ja keltaisen (+b) värin pitoisuudet olivat pohjoisessa selvästi suurimmat. Mansikalla olivat marjojen punaisen (+a) ja keltaisen (+b) väriaineen määrät korkeimmat Muddusniemessä ja Rovaniemellä.

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THE ORNAMENTAL TREES AND SHRUBS GROWN AT THE INSTITUTE OF HORTICULTURE IN THE YEARS 1927—1976

TAPIO K. KALLIO

KALLIO, T. K. 1977. **The ornamental trees and shrubs grown at the Institute of Horticulture in the years 1927—1976.** Ann. Agric. Fenn. 16:27—36. (Agric. Res. Centre, Inst. Hortic., SF-21500 Piikkiö, Finland.)

Since 1927, research has been done on the performance of ornamental trees and shrubs at the Institute of Horticulture, Piikkiö, Finland, and the paper presents the results obtained with 384 tree and shrub species. Of these, 160 have done well, 88 have done fairly well and 136 have done poorly or died completely. In the most severe winters of 1939—1940 (minimum temperature —34,4 °C) and 1965—1966 (—35,5 °C), large numbers of trees and shrubs were damaged by the frost.

Index words: ornamental trees and shrubs, winterhardiness.

INTRODUCTION

Owing to Finland's geographical position between 60 and 70 degrees of latitud, many plants have the northern limit of their outdoor cultivation in this country, especially those of foreign origin, such as the majority of the plants grown as ornamentals in Finland (KALLIO 1975).

When plants are grown near the limits of their area of successful cultivation, various factors affecting growth increase in importance, especially those relating to the environment. The climate, particularly the temperature, plays a decisive role, the most significant factors being the minimum winter temperatures, the length of the period of frost, the time of the arrival of winter, and also the length and temperature of the growing season. Another important factor in Finland is the snow cover, thanks to which low shrubs can do well much farther north than would otherwise be possible (KALLIO 1966a).

Success also depends on the local conditions, since temperature may show wide local variation. For example, many plants have done surprisingly well in yards sheltered by buildings, where the temperature is well above that in the surroundings (KALLIO 1966).

The performance of a species is also closely connected with its genetic properties. Thus the origin or provenance of an individual has been shown to be more or less decisive for its success (HEIKINHEIMO 1955). The economic importance of provenance is particularly great in forestry.

In Finland, rather little attention has been paid to the success of ornamental trees and shrubs throughout the country (KALLIO 1966a, 1975). Among the ornamentals at the arboretum at Mustila, only the evergreens have received a detailed study (Tigerstedt 1922). Papers have also been published on the performance and damage suffered by restricted groups of ornamentals (Komppa 1926, Saarnijoki 1937, Schalin 1936, Vaarama 1941). The first report on the trees and shrubs grown at the Institute of Horticulture was published in 1963 (Meurman).

MATERIAL AND METHODS

The Institute of Horticulture is located at Piikkiö on the southwest coast of Finland, beside a bay sheltered by the archipelago. The mean temperature for the years 1931—1960 was 4,9 °C. The monthly means (°C) for the same period were:

January	−5,7
February	−6,3
March	−3,3
April	2,6
May	9,2
June	14,0
July	17,3
August	15,9
September	11,0
October	5,6
November	1,2
December	−2,3

The majority of the trees and shrubs are planted in the park surrounding the Institute buildings, but some species are also grown beside the shore and in an area expressly reserved for this purpose in the forest. The ground is mineral soil, ranging from fine sand to clayey till.

Some ornamental species were grown in the grounds of the Institute even before 1927 (Meurman 1963). Since this date, about 400 species and varieties of trees and shrubs have been planted in the park and in trials. This number does not include the numerous rose variety trials, whose results have been published earlier (Kallio 1973). The plants most extensively studied have been the genera *Spiraea, Potentilla, Philadelphus* and *Malus.*

The plants were generally received as gifts from Finnish nurseries, and the number of individuals per species was only 1—5. This clearly makes it difficult to evaluate the results, since the chance loss of one plant need not necessarily mean that this species cannot thrive in the area. Another point affecting the interpretation of the results is the absence of data on the provenance of plants raised from seed.

During the study period the collection of ornamentals at the Institute suffered from two very hard cold spells, during which the less hardy plants died. The first occurred in winter 1939—1940, the second in 1965—1966, when the minimum temperatures were −34,4 °C and −35,5 °C, respectively.

In this report three ranks have been used in assessing the performance of the plants. Plants said to have done well have survived without damage from one year to another; those said to have done fairly well have suffered to some extent during the most severe winters, for instance, the current year's growth has been killed by frost; those said to have done poorly have almost regularly been killed back to the ground, or have died completely.

RESULTS AND DISCUSSION

Deciduous trees and shrubs

Acanthopanax Miq. *A. henryi* (Oliv.) Harms was planted in 1937. It survived the hard frosts of the years 1939—1942 without damage. By 1961, it had reached 1,5 m (MEURMAN 1963). Later, however, frost killed it back to the ground and it died completely in 1970.

Acer L. *A. platanoides* L. grows wild around the Institute. Its red-leaved varieties 'Schwedleri' and 'Faassens Black' have done well. In contrast, 'Drummondii' did badly and died a few years after planting, but this was mainly due to mechanical damage. *A. negundo* L. var. *pseudo-californicum* Schwer. grew at the Institute; the tree, which was planted in 1935, had to be felled in 1959, when its trunk had already reached 51 cm in diameter (MEURMAN 1963). *A. tataricum* L. and *A. ginnala* Maxim. have been almost completely hardy, but vigorous shoot growth of the current year has occasionally been killed by frost in *A. ginnala.* MEURMAN (1963) considers that *A. tataricum* is much hardier than *A. ginnala.* In 1935 one male plant of *A. rubrum* L. was planted in the yard of the Institute; it did fairly well. In 1967 some scores of seedlings were planted, which had been raised from the seed of trees grown in Finland; these also did fairly well. *A. campestre L., A. japonicum* Thunb. 'Areum' and *A. pensylvanicum* L. were tried at the Institute, but all died a few years after planting. *A. saccharinum* L. was planted in 1974.

Actinidia Lindley. In 1950 two individuals of *A. kolomikta* (Maxim. & Rupr.) Maxim. were planted by the north wall of one of the Institute buildings, in a particularly shady site. At first they grew well and even flowered (MEURMAN 1963), but later they began to do poorly, on account of the competition offered by nearby shrubs and trees, and in 1970 they died. However, *A. kolomikta* has generally done well in different parts of Finland (KALLIO 1966).

Aesculus L. *A. hippocastanum* L. and *A.* × *carnea* Hayne 'Briotii' were planted at the Institute in the 1930s, but did not survive more than a few years (MEURMAN 1963). However, *A. hippocastanum* is known to have done fairly well in South Finland (KALLIO 1966).

Ailanthus Desf. The Institute has had no success at all with *A. altissima* (Mill.) Swingle and *A. vilmoriniana* Dode (MEURMAN 1963).

Alnus B. Ehrh. *A. incana* (L.) Moench 'Pinnatipartita' has done well. This rare Finnish variety of the Grey Alder grows slowly, because the leaves with their deeply divided lobes have only a small surface for assimilation.

Amelanchier L. *A. laevis* Wieg. was planted in 1950, and the shrubs have grown fairly well. *Sorbus aucuparia* L. was used as a rootstock.

Amorpha L. *A. fruticosa* L. was planted in 1938 and killed by frost in 1940 (MEURMAN 1963).

Aralia L. An individual of *A. chinensis* L. was planted in 1935 and overwintered well under cover until 1940. After this, it was killed back to the ground each year (MEURMAN 1963), until it finally died in 1966.

Aristolochia L. Plants of *A. durior* Hill. were growing at the Institute before 1927. Both these and later plantings have done well.

Aronia Med. The three species *A. arbutifolia* (L.) Pers., *A. melanocarpa* (Michx.) Ell. and *A. prunifolia* (Marsh.) Rehd. have all done well.

Berberis L. *B. thunbergii* DC. is abundantly represented at the Institute. In the hardest winters its shoots have died back to the surface of the snow cover, but it is perfectly suitable for cultivation, as the shoots of the current year flower and set fruit. The red-leaved *B. thunbergii* 'Atropurpurea' is somewhat more delicate; plants set in 1950 died back to the ground in 1966 and died completely two years later. *B.* × *ottawensis* Schneid. is somewhat hardier than *B. thunbergii;* the varieties 'Superba' and 'Decora' have done well. In 1937—1938, the Institute acquired a collection of *Berberis,* comprising *B. aggregata* C. Schneid., *B. buxifolia* Lam. 'Nana', *B. concinna* Hook.f., *B. diaphana* Maxim., *B. verruculosa* Hemsl. & Wils. and *B. wilsoniae* Hemsl. & Wils. They were all killed by frost after a few years (MEURMAN 1963). Only *B. koreana* Palibin survived until the 1970s. This species has been reported to be hardy (KALLIO 1966).

Betula L. Several native birch forms have been planted at the Institute: *B. verrucosa* Ehrh. 'Birkalensis', 'Laciniata' and 'Youngii' and *B. pubescens* Ehrh. 'Urticifolia'. They have all been almost equally hardy. *B. papyrifera* Marsh. has also done well, whereas *B. nigra* L. has done poorly.

Buddleia L. All the three species tried at the Institute, *B. alternifolia* Maxim., *B. davidii* Franch. var. *magnifica* (Wils.) Rehd. & Wils. and *B. farreri* Balf. f. & W. W. Sn., were killed by the frost within a few years (MEURMAN 1963).

Buxus L. *B. sempervirens* L. 'Suffruticosa' has generally done well if covered for the winter. Without a cover it died. *B. microphylla* S. & Z. was planted on two occasions, but both times the plants died after a few years.

Caragana Lam. *C. arborescens* Lam., often used for hedges, has survived the winters perfectly, as has also the variety 'Lorbergii' and the species *C. frutex* (L.) K. Koch and *C. pygmaea* (L.) DC.

Catalpa Scop. In 1936, an individual of *C. ovata* G. Don was planted; its shoots were killed each winter and it died completely in 1966. This is probably the only individual ever tried in Finland (MEURMAN 1963).

Celatrus L. *C. orbiculata* Thunb. has survived the winters perfectly at the Institute.

Cercidiphyllum S. & Z. *C. japonicum* S. & Z. has been tried twice. The plant set in 1938 died after a couple of years, whereas that set in 1963 has done fairly well.

Chaenomeles Lindl., *C. japonica* Lindl. has generally done well, because in winter the low bushes are protected by the snow. A small *Chaenomeles* trial was made at the Institute (KALLIO 1968b). *C. japonica* and the variety 'Rubra' were the hardiest, whereas *C. speciosa* (Sweet) Nakai and *C.* × *superba* (Frahm) Rehd. varieties overwintered rather badly.

Clematis L. MEURMAN (1963) mentions trials at the Institute, which included *C. alpina* Mill., *C. viticella* L., *C. paniculata* Thunb., *C. flammula* L., *C. ligusticifolia* Nutt., *C. vitalba* L., *C. serratifolia* Rehd. and *C. tangutica* (Maxim.) Korsh., but gives a value for *C. tangutica* alone and does not give any details of the performance of the species. *C. montana* Buch.-Ham. has often proved to be too delicate. The shoots of *C.* × *jackmanii* Moore have generally died in the winter, but even when killed down to the ground it has shooted and flowered each year.

Cornus L. *C. alba* L., its variegated form 'Argenteomarginata' and *C. stolonifera* Michx. 'Flaviramea' have all done well. *C. mas* L. is much more sensitive; it was killed back to the ground in 1944 (MEURMAN 1963) and 1966, but has always formed new shoots.

Corylus L. *C. avellana* L. 'Contorta' has done well.

Cotoneaster Ehrh. Many *Cotoneaster* species have been planted at the Institute. *C. integerrimus* Med. and *C. lucidus* Schlechtd. have proved to be the hardiest. Species found to be sensitive and surviving only a few years are: *C. apiculatus* Rehd. & Wils., *C. bullatus* Bois., *C. dielsianus* Pritz., *C. multiflorus* Bge and var. *calocarpus* Rehd. & Wils., *C. prostrata* Baker, *C. salicifolius* Franch. var. *flococcus* Rehd. & Wils. and *C. zabelii* Schneid. *C. divaricatus* Rehd. & Wils. has been planted several times; some of the bushes have died, but some, planted in a favourable site, have survived. *C. tomentosus* (Ait.) Lindl. has suffered most from frost damage each winter. The low *C. adpressus* Bois. and *C. praecox* Vilmorin-Andrieux have generally survived well under the snow. An individual of *C. adpressus* planted in 1937 has now, 40 years later, grown to a carpet 3 m in diameter. *C. horizontalis* Decne. has done less well than the two preceding species. The evergreen *C. dammeri* Schneid. 'Skogsholmen' has done well in spite of its windy site.

Crataegus L. The plant most commonly used for hedges in Finland, *C. intricata* Lge. has survived without any damage, as has also *C. douglasii* Lindl. *C. prunifolia* has proved to be delicate (MEURMAN 1963). The old single-stemmed *C. oxyacantha* L. 'Pauls's Scarlet' was killed by frost in 1940. The bushy individuals subsequently planted have overwintered satisfactorily, but their flower buds have been damaged by frost in many winters.

Cytisus L. The low-growing *C. decumbens* (Durante) Spach and *C. purpureus* Scop. have done well. According to MEURMAN (1963), *C. hirsutus* L. is extremely hardy, surviving the most severe winters without damage. In contrast, *C. supinus* was killed by the frost in the first winter after planting out.

Decaisnea Thunb. An individual of *D. fargesii* Franch. was planted in 1937. Although protected in the winter, it died completely in 1944 (MEURMAN 1963).

Deutzia Thunb. Of the many species of *Deutzia* planted at the Institute, only *D. gracilis* S. & Z. has survived for many years, flowering abundantly. *D. discolor* Hemsl. 'Major', *D.* × *rosea* (Lemoine) Rehd. 'Campanulata' and *D. scabra* Thunb. 'Plena' have all been killed (MEURMAN 1963).

Elaeagnus L. *E. commutata* Bernh. tolerates the Finnish climate very well (MEURMAN 1963). The bush was removed on account of building work in 1967.

Euonymus L. *E. europaeus* L. was planted in 1937 and has done well. *E. sachalinensis* (F. Schmidt) Maxim. and *E. planipes* Koehne were planted later and have done well or fairly well. In contrast, *E. alatus* (Thunb.) Sieb. died only four years after planting.

Exochorda Lindl. A bush of *E. racemosa* (Lindl.) Rehd. was planted in 1937 and remained alive until 1971. It was often damaged badly by frost in the winter, but its bed was in a very shady place.

Fagus L. An individual of *F. silvatica* L. 'Atropunicea' has been growing in the Institute park since 1930. It has generally overwintered fairly well, but the height of the bush does not yet exceed one metre.

Forsythia Vahl. *F. ovata* Nakai has been growing at the Institute for 46 years. It has never done less than fairly well and has flowered every year. In contrast, *F.* × *intermedia* Zab. 'Spectabilis' and *F. suspensa* (Thunb.) Vahl, which were planted in 1937—1939 had both died by 1970. Their shoots sometimes overwintered without frost damage, but the flower buds were always harmed, so that flowering occurred only on the shoots close to the ground, which had been protected by the snow cover.

Fraxinus L. *F. pensylvanica* Marsh. has done fairly well from 1963 onwards.

Gleditsia L. *G. triacanthos* L. was planted in 1935, but died in 1942, without ever having flowered (MEURMAN 1963).

Hibiscus L. MEURMAN (1963) tried growing *H. syriacus* L. in the 1930s, but it was killed by frost in 1940.

Holodiscus Maxim. *H. discolor* (Pursh) Maxim. var. *ariaefolius* (Sm.) Aschers. & Graebn. was planted in 1963. Although the bushes have regularly died back to the snow in winter, they have flowered every year.

Hydrangea L. *H. arborescens* L. 'Grandiflora' has been planted several times at the Institute. Though dying back to the snow every winter, it has grown for a few years until a severe winter has killed it completely, the last time being in 1966. *H. paniculata* Sieb. 'Grandiflora' was planted in 1933. The greater part of its bushes are still alive, and have done fairly well. *H. anomala* D. Don ssp. *petiolaris* (S. & Z.) McClintock has done fairly well, growing round the trunk of a pine.

Hypericum L. *H. patulum* Thunb. var. *henryi* Veitch grew for a few years in the 1950s and even flowered.

Juglans L. *J. mandshurica* Maxim. was planted in 1935, but the plants died completely in 1940 (MEURMAN 1963). *J. cinerea* L. which was planted at the same time, is still alive and has grown to a good-sized tree. Since the severe winter of 1966, it has not done more than fairly well, but it has flowered and set fruit every year. New plants set in 1968 have done better. A third species, *J. nigra* L., has survived with difficulty from 1948.

Kalmia L. The Institute has tried to grow *K. angustifolia* L., but without success. *K. polifolia* Wangh. has also done poorly (MEURMAN 1963).

Kerria DC. An attempt to grow *K. japonica* DC. 'Pleniflora' was defeated by the hard winters of 1940—1942.

Kolkwitzia Graebn. MEURMAN's (1963) attempts to grow *K. amabilis* Graebn. at the Institute were unsuccessful, and the plants did not even flower. One bush was planted in an especially sheltered place, beside a stone wall, in 1968; and has done well or fairly well, flowering every year.

Laburnum Med. *L. alpinum* (Mill.) Bercht. & Presl. has done poorly (MEURMAN 1963).

The bushes have died back to the ground in severe winters, the last time being in 1966, and have flowered in only a few summers.

Ligustrum L. *L. vulgare* L. has done fairly well, but has died back to the ground in the most severe winters (MEURMAN 1963).

Lonicera L. Species surviving without damage are *L. coerulea* L., *L. involucrata* (Richards) Banks, *L. maackii* (Rupr.) Maxim., *L. morrowii* Gray and *L. tatarica* L. (MEURMAN 1963). Of the climbing plants, *L. caprifolium* L. has done fairly well, but *L.* × *americanum* (Mill.) K. Koch and *L. periclymenum* L., which were tried in the 1960s, died within a few years. *L.* × *tellmanniana* Magyar has survived for a few years in an especially sheltered place.

Magnolia L. According to MEURMAN (1963), an attempt to grow an individual of *M. kobus* DC. was unsuccessful.

× *Mahoberberis* Schneid. × *M. neubertii* (Lem.) Schneid., which is easily propagated from suckers, has done fairly well, although its shoots have died down in hard winters.

Mahonia Nutt. *M. aquifolium* (Pursh) Nutt. has done well when the plants have been protected by the snow in winter.

Malus Mill. Many plants of *M. baccata* (L.) Borkh. and *M. prunifolia* (Willd.) Borkh. were set at the Institute in 1930 (MEURMAN 1963). The greater part of them are still in excellent condition. Since they are seedlings, their characters vary widely, especially the colour and size of the fruit. The smallest fruits have a diameter of only 6—7 mm. In 1965, the Institute procured a large collection of ornamental apple trees (KALLIO and KARHINIEMI 1976). The following species and varieties died within the first four years: *M.* × *adstringens* Zabel 'Crimson Brilliant' and 'Helen', *M.* × *atrosanguinea* (Späth) Schneid., *M.* × *hartwigii* Koehne 'Katherine', *M. hupehensis* (Pam.) Rehd. 'Rosea', *M.* × *purpurea* (Barbier) Rehd. 'Aldenhamensis', 'Eleyi', 'Lemoinei' and 'Nicoline', *M.* × *scheideckeri* Späth ex Zabel 'Hillieri', *M. sieboldii* (Regl.) Rehd. 'Van Eseltine', *M.* × *soulardii* (Bailey) Britt. 'Redflesh' and 'Wynema'. The greater part of the collection was killed by voles in winter 1974—1975. Up till then, the hardiest trees were found to be *M.* × *adstringens* 'Almey', 'Hopa', 'Nipissing' and 'Wabiscaw', *M. baccata* var. *jackii* Rehd., *M.* × *gloriosa* Lemoine 'Oekonomierat Echtermeyer', *M. prunifolia* 'Hyvingiensis' and 'John Downie', *M. pumila* Mill. 'Cowichan' and 'Scugog', *M. purpurea* 'Kornicensis' and 'Wierdak', *M.* 'Red Jade' and *M. sargentii* Rehd. Trees that were somewhat less hardy, but still did satisfactorily were *M. floribunda* Van Houtte, *M.* × *moerlandsii* Doorenbos 'Liset' and 'Profusion', *M. pumila* 'Makamik', 'Oksala' and 'Kobendza', *M. sieboldii* 'Wintergold' and *M.* × *zumi* (Matsum.) Rehd. var. *calocarpa* Rehd.

Mespilus L. An individual of *M. germanica* L. was planted in 1938 but died after a couple of years (MEURMAN 1963).

Pachysandra Michx. *P. terminalis* S. & Z. has done very well from 1963 onwards in the bush layer of a fairly damp ash wood *(Fraxinus)*.

Parthenocissus Planch. Both *P. quinquefolia* (L.) Planch and *P. vitacea* Hitchcock have generally done well, but an attempt to grow *P. tricuspidata* (S. & Z.) Planch 'Veitchii' at the Institute met with little success. This climber could be kept alive a few years, if covered with a layer of straw in winter.

Philadelphus L. The *Philadelphus* species in Finland are very variable and difficult to identify (KALLIO 1970a). *P. coronarius* L. has been growing at the Institute for a long time, and has done well (MEURMAN 1963). The species most commonly grown in Finland has not been identified. It is most often called *P. inodorus* L. var. *grandiflorus* (Willd.) Gray, but this determination is incorrect. MEURMAN (1963) considers that this comparatively hardy species is *P. gordonianus* Lindl., but the sparse racemes show clearly that this is also a misidentification. The true *P. inodorus* var. *grandiflorus* is very rare in Finland. In 1968, a collection was made of all the *Philadelphus* species for which Finnish-grown material was available. Of these, *P. pubescens* Loisel. proved to be another hardy species. *P.* × *virginalis* Rehd. has done fairly well, whereas *P.* × *lemoinei* Lemoine hybrids have generally been found to be delicate. *P* × *lemoinei* 'Erectus' and *P.* × *maximus* Rehd. have both done fairly well at the Institute from 1951 onwards.

Physocarpus (Cambess.) Maxim. Three bushes planted in 1930 are still doing very well.

Populus L. An attempt to grow *P. alba* L. 'Nivea' in the 1930s was unsuccessful, owing to its poor winter hardiness (MEURMAN 1963). *P. canescens* (Ait.) Smith has clearly proved to be hardier; the first individuals were planted in 1964 and so far they have done well. Two *Populus* species that are rare for Finland are growing at the Institute: *P. simonii* Carr. has done well since 1943, but the performance of the two individuals of *P. nigra* L. 'Italica' has been less satisfactory. The two trees were planted in 1939 and have already grown to 20 metres, but in recent winters their branches have suffered considerably from the frost. A collection of *Populus* species was planted in 1967. Of these, *P. balsamifera* L. and *P.* × *rasumowskiana* (Regel) Dipp. have survived without any damage. Species which have done slightly less well are *P.* × *berolinensis* Dipp., *P.* × *generosa* Henry, *P. laurifolia* Ledeb. and *P. trichocarpa* Torr. & Gray. Species which have died or done very poorly are *P.* × *canadensis* Moench and its varieties 'Eugenei', 'Robusta' and 'Siouxland', *P. deltoides* Marsh. and *P. simonii* 'Fastigiata'.

Potentilla L. A variety trial of *P. fruticosa* L. was established in 1964 (KALLIO 1968a). The majority of the forms and varieties have done well: var. *arbuscula* D. Don, 'Friedrichsenii', 'Jackman', 'Katherine Dykes', 'Mount Everest', 'Primrose Beauty', 'Sandved' and 'Summergold'. Plants that have proved to be delicate are var. *davurica* (Nestler) Ser., 'Farreri', 'Klondike' and 'Walton Park'.

Prunus L. MEURMAN (1963) reports that the following species have done well at the Institute: *P. sargentii* Rehd., *P. virginiana* L. var. *melanocarpa* (A. Nels.) Sarg., *P. tenella* Batsch, and *P. americana* Marsch. In a new *Prunus* collection planted in 1966—1967, other species that have done well are *P. maackii* Rupr., *P. padus* L. 'Colorata' and *P. virginiana* 'Schubert'. Species dying within a few years were *P. laurocerasus* L. 'Schipkaensis' (MEURMAN 1963), *P.* × *cistena* (Hansen) Koehne, *P. serrulata* Lindl., *P. subhirtella* Miq. 'Autumnalis', *P. tomentosa* Thunb. and *P. triloba* Lindl.

Ptelea L. *P. trifoliata* L. has done fairly well in a very sheltered place since 1933.

Quercus L. The native *Qu. robur* L. has been planted abundantly in the grounds of the Institute (MEURMAN 1963). Since 1963, its form 'Fastigiata' has done fairly well.

Rhododendron L. At the Institute the *Rhododendron* bushes are generally covered with conifer branches for the winter. According to MEURMAN (1963), the following species have done well *R. brachycarpum* D. Don, *R. canadense* Torr., *R. catawbiense* Michx. and *R. molle* (Bl.) G. Don. *R.* × *myrtifolium* Lodd. and *R. schlippenbachii* Maxim. died within a few years, and the variety 'Cunningham's White' also did poorly. *R. brachycarpum* 'Tigerstedtii' and *R. maximum* L. were planted at the Institute 3 years ago and have so far done well.

Rhus L. *R. typhina* L. belonged to the Institute's collection, but did not do well (MEURMAN 1963).

Ribes L. Only two species have been grown as ornamentals at the Institute, *R. alpinum* L 'Pumilum' and *R. aureum* Pursh; both have done well.

Robinia L. MEURMAN (1963) tried two *Robinia* species: *R. neomexicana* A. Gray var. *luxurians* Dieck and *R. pseudoacacia* L., but neither was found to be hardy.

Rosa L. A detailed report has been given of the rose variety trials undertaken at the Institute (KALLIO 1973). In addition, many roses are grown in the park of the Institute. The hardiest roses have proved to be *R.* × *collina* Jacq., *R. gallica* L. 'Splendens', *R. glauca* Pourr., *R. pimpinellifolia* L. 'Plena', *R. rugosa* Thunb. and the variety 'Hansa'. Species that have done satisfactorily are *R. alba* L. 'Suaveolens', *R. centifolia* L. 'Muscosa', *R. gallica* 'Scharlachglut' and *R. villosa* L. 'Pomifera'. Many other species and varieties proved to be rather delicate and were often badly damaged by the frost, e.g. *R. centifolia* and *R. pimpinellifolia*.

Salix L. The saplings of *S. alba* L. 'Sericea' planted in 1933 have grown into tall trees. But the bushes of *S. purpurea* L. did poorly (MEURMAN 1963). A number of species planted in the 1960s have done well: *S. alba*, *S. alba* 'Vitellina', *S. fragilis* L., *S. fragilis* 'Bullata' and

S. nigra Marsh. *S.* × *smithiana* Willd. is growing in the international phenological garden. It has suffered some damage in the winter, as has also *S. viminalis* L. A *Salix* collection was recently planted at the Institute, but no information is yet available on the performance of the species.

Sambucus L. *S. racemosa* L. grows as a naturalized species. *S. nigra* L. has done poorly. *S. canadensis* L. 'Maxima', which was planted in 1933, has died back to the ground several times, but after milder winters it has even flowered.

Sorbaria (Ser.) A. Br. *S. arborea* Schneid. var. *glabrata* Rehd. was killed by the frost a few years after it was planted (MEURMAN 1963). *S. aitchisonii* Hemsl. Has died back to the ground, but has still managed to flower.

Sorbus L. Besides the native plants of *S. aucuparia* L., the species growing at the Institute include *S. aria* (1.) Crantz and *S.* × *thuringiaca* (Ilse), Fritsch, which have done well. *S. pratti* Koehne has done fairly well, but *S. alnifolia* (S. & Z.) K. Koch var. *submollis* Rehd. died a few years after it was planted. The *S. aucuparia* varieties 'Pendula', 'Pink Coral' and 'Red Tip' have overwintered well.

Spiraea L. A *Spiraea* collection was planted at the Institute in 1964 (KALLIO 1967), but earlier observations on the performance of *Spiraea* species are also available (MEURMAN 1973). The following species have done well: *S.* × *billardii* Herinq, *S. chamaedryfolia* L., *S.* × *cinerea* Zab. and its variety 'Grefsheim', *S. decumbens* W. Koch, *S. douglasii* Hook., *S. media* Schmidt, *S. trilobata* L. and *S. zabeliana* Schneid. The following species have done fairly well: *S.* × *arguta* Zab., *S.* × *bumalda* Burvenich 'Froebelii', *S. henryi* Hemsl., *S. hypericifolia* L., *S.* × *margaritae* Zab., *S. nipponica* Maxim., *S. rosthornii* Pritz and *S. trichocarpa* Nakai. Although almost regularly damaged by the frost in winter, the following species have flowered: *S. albiflora* (Miq.) Zab., *S.* × *bumalda* 'Anthony Waterer', *S. japonica* L. f. 'Ruberrima' and *S. wilsonii* Duthie.

Species which have done poorly are: *S. japonica* 'Macrophylla', *S. prunifolia* S. & Z., *S. sargentiana* S. & Z., *S.* × *vanhouttei (Briot) Zab. and S. veitchii* Hemsl.

Symphoricarpos Duham. *S. albus* (L.) Blake var. *laevigatus* (Fern.) Blake has done fairly well.

Syringa L. The following plants have done well at the Institute: *S. vulgaris* L., *S. josikaea* Jacq. f. and *S. amurensis* Rupr. var. *japonica* (Maxim.) Franch. & Sav. Species in which the current year's shoot growth has now and then been damaged by the frost are *S. reflexa* Schneid., *S. sweginzowii* Koehne & Lingelsh., and *S. wolfii* Schneid. The *S. vulgaris* varieties 'Marie Legraye', 'Charles X' and 'Michel Buchner' proved to be less hardy and died after about 15 years. *S.* × *chinensis* Willd. 'Saugeana' and *S.* × *hyacinthiflora* (Lemoine) Rehd. did not live more than a few years.

Tamarix L. Two *Tamarix* species were tried at the Institute in the 1930s. *T. parviflora* DC. proved to be delicate and was regularly damaged by the frost, but *T. pentandra* Pall. survived somewhat longer, flowering every year up to the end of the 1940s.

Tilia L. MEURMAN (1963) reported that trees of *T. cordata* Mill. growing at the Institute had been planted in the middle of the 19th century, but these were later found to be *T.* × *europaea* L. More of these have been planted and have proved to be much hardier than trees of *T. platyphylla* Scop. (KALLIO 1970), whose trunks have suffered badly from woodrot.

Weigela Thunb. The species and varieties planted in the 1930s, *W. coraeensis* Thunb. 'Eva Rathke', *W. florida* (Bge) A. DC. 'Venusta', *W. middendorffiana* (Trautv. & C.A. Mey.) L. Koch and *W. praecox* (Lemoine) Bailey 'Bouquet rose' were killed by winter 1940—1942 (MEURMAN 1963). The three varieties were later planted again: 'Eva Rathke' died within a few years, but 'Venusta' and 'Bouquet rose' have done fairly well in a sheltered place.

Viburnum L. Several *Viburnum* species have done well at the Institute: *V. acerifolium* L., *V. rafinesquianum* Schult. var. *affine* (Schneid.) House and *V. trilobum* Marsh. (MEURMAN 1963). Species doing fairly well were *V. carlesii* Hemsl., *V. cassinoides* L. and *V. opulus* L. 'Roseum'. Species doing poorly and finally dying were *V. lentago* L., *V. rhytidophyllum* Hemsl., *V. plicatum* Thunb. 'Mariesii' and f. *tomentosum* (Thunb.) Miq.

Vitis L. Plants of *V. labrusca* L. 'Beta' were set in 1939 against a warm wall, and were at first protected in winter with conifer branches (MEURMAN 1963). They have occasionally suffered some frost damage, but have always recovered.

Yucca L. *Y. filamentosa* was planted in 1943 and survived till the beginning of the 1960s. Although covered in winter and protected by the snow, it never once flowered (MEURMAN 1963).

Conifers

Abies Mill. *A. concolor* (Grod.) Hoopes and *A. sibirica* Ledeb. were planted in 1931 and have done very well (MEURMAN 1963). *A. nordmanniana* (Stev.) Spach, planted at the same time, grew slowly and suffered frost damage almost every winter, finally dying in 1966. Other species of *Abies* were not planted at the Institute until the 1960s. Species that have done well are *A. amabilis* (Lood.) Forbes, *A. balsamea* (L.) Mill., *A. koreana* Wils. and *A. sachalinensis* (Fr. Schmidt) Mast.; species doing fairly well are *A. alba* Mill., *A. nephrolepis* Maxim. and *A. veitchii* Lindl.

Chamaecyparis Spach. *C. lawsoniana* (Murr.) Parl. 'Alumii' was planted in 1940 and is still alive, but has not grown beyond two metres. The other species growing at the Institute are still so small that they are protected by the snow in winter, and no clear picture has yet been obtained of their performance.

Juniperus L. *J. chinensis* L. 'Pfitzeriana' has been planted several times at the Institute, and has generally done fairly well, but the oldest individual, planted in 1940, has already died. *J. sabina* L. has also done only fairly well. Its shoots show a tendency to turn brown, which was also noted by MEURMAN (1963). *J. virginiana* L. and its variety 'Grey Owl' have done rather poorly. *J. squamata* Buch.-Ham. var. *meyeri* Rehd. has proved to be even less hardy and most of its plants have died or survive only with difficulty.

Larix Link. *L. sibirica* Ledeb. is one of the hardiest plants at the Institute. *L. decidua* Mill. has so far done well in the phenological garden, although its needles have remained attached to the branches in winter.

Picea A. Dietr. *P. abies* (L.) Karst. 'Echiniformis', 'Nidiformis' and 'Pygmaea' have done very well. Trees of *P. glauca* (Moench) Voss were planted as a windbreak in the field and have done well, as has also *P. omorika* (Pančic) Purkyne. *P. mariana* (Mill.) B.S.P. has done poorly in a shady place, but *P. sitchensis* (Bong.) Carr has done even less well. *P. pungens* Engelm. and its form 'Glauca' have proved to be fairly hardy.

Pinus L. The foreign *Pinus* species planted at the Institute have generally been fairly hardy: *P. cembra* L., *P. contorta* Dougl. var. *latifolia* Engelm., *P. mugo* Turra and *P. peuce* Griseb. But *P. ponderosa* Dougl. proved to be too delicate (MEURMAN 1963). *P. silvestris* L. 'Pumila' also overwintered poorly.

Pseudotsuga Carr. *P. menziesii* (Mirb.) Franco f. *caesia* Franco has generally done poorly.

Taxus L. *T. baccata* L. 'Overeynderi' has done fairly well since 1961. The oldest individuals of *T. cuspidata* S. and Z. were planted in 1946; they have done well, overwintering without any frost damage. *T.* × *media* Rehd. 'Hicksii' is somewhat less hardy. But although its needles have frozen in some winters, it has recovered well. *T.* × *media* 'Hillii', which is still protected by the snow cover in winter, has done well.

Thuja L. Several different forms of *T. occidentalis* L. have been tried at the Institute, and have generally proved to be hardy: 'Fastigiata', 'Globosa', 'Holmstrupii' and 'Woodwaardii'. Only 'Recurva nana' has done poorly. *T. koraiensis* Nakai has done fairly well. Hybrids between the two species have so far done well. *T. plicata* D. Don has grown very slowly, although it has suffered no frost damage in winter.

Thujopsis S. & Z. Bushes of *T. dolobrata* S. & Z. have proved extremely persistent, but have never grown above the limit of the snow cover.

Tsuga Carr. Two individuals of *T. diversifolia* (Maxim.) were planted in 1936. One of them died after a few years (MEURMAN

1963), but the other is still alive. However, it is no more than a large bush, since the crown and some of the branches have been damaged in hard winters, this last happening in 1966. Young individuals of *T. canadensis* (L.) Carr. are doing well.

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SELOSTUS

Koristepuut ja -pensaat Puutarhantutkimuslaitoksessa vuosina 1927—1976

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Maatalouden tutkimuskeskus

Koristekasvien, varsinkin puiden ja pensaiden menestyminen Suomessa on rajoitettua. Useimmat niistä ovat peräisin ilmastollisesti Suomea edullisemmilta seuduilta ja tämän vuoksi niiden talvenkestävyys saattaa olla jopa varsin heikko. Vaihtelut ovat kuitenkin suuria. Puutarhantutkimuslaitoksessa Piikkiössä on vuodesta 1927 alkaen tutkittu koristepuiden ja -pensaiden menestymistä istuttamalla niitä laitoksen tonttialueelle perustettuun puistoon ja metsään, jonne niitä varten on varattu erilliset alueet. Laajimman tarkastelun kohteina ovat olleet kasvisuvut *Malus*, *Philadelphus*, *Potentilla* ja *Spiraea*. Tässä kirjoituksessa on selostettu yhteensä 384 puu- ja pensaslajin viihtymistä. Niistä on 160 menestynyt hyvin, 88 kohtalaisesti ja 136 heikosti tai tuhoutunut kokonaan. Heikkoon menestymiseen on voinut vaikuttaa heikon talvenkestävyyden lisäksi myös sopimaton kasvupaikka. Ankarimmat talvet olivat vuosina 1939—1940 (minimilämpötila —34,4°C) ja 1965—66 (—35,5°C), joiden aikana paleltui runsaasti koristepuita ja -pensaita.

ANNALES AGRICULTURAE FENNIAE, VOL. 16:37—48 (1977)
Seria HORTICULTURA N. 34 — Sarja PUUTARHAVILJELY n:o 34

TRIALS WITH SOME RESIDUAL HERBICIDES IN NURSERY PLANTS

ANNELI KARHINIEMI

KARHINIEMI, A. 1977. **Trials with some residual herbicides in nursery plants.** Ann. Agric. Fenn. 16:37—48. (Agric. Res. Centre, Inst. Hortic., SF—21500 Piikkiö, Finland.)

It was noted that, with some restrictions, chlorthiamid and dichlobenil were suitable for weed control in deciduous nurseries. In 1968—1972 these herbicides were tested on 32 newly planted transplants of woody ornamental and berry species. Slightly less investigations were made with dichlobenil than with chlorthiamid.

With a dosage of 3 kg/ha of chlorthiamid good control was gained of annual weeds, and with 6 kg/ha the results were excellent. Autumn treatments had a better initial effect than spring treatments. The effect of dichlobenil in autumn was poor on the species *Epilobium montanum* and *Poa annua.* With spring treatments, *Capsella bursa-pastoris* and *Epilobium* were the most resistant to chlorthiamid. The drought after the spring application weakened the effect of herbicides. Weeds which has already emerged and perennial weeds were not killed completely. Among perennial weeds, *Cirsium arvense* was very resistant to small doses. With 3 kg/ha of chlorthiamid the residual effect lasted one season (4—5 months) and with 9 kg/ha about two seasons.

The most susceptible crops were *Berberis thunbergii, Cornus alba, Mahonia aquifolium, Potentilla fruticosa* and *Spiraea* × *bumalda* 'Froebelii'. Their growth was already weakened by the smallest dosage, 3 kg/ha of chlorthiamid applied in autumn, though the spring treatment did not affect them. 6 kg/ha damaged these same crops more seriously. Dichlobenil was somewhat safer in autumn than chlorthiamid; in spring *Berberis* and *Chaenomeles japonica* was damaged after its use. The most resistant crops seemed to be representatives of the generas *Acer, Amelanchier, Caragana, Philadelphus, Ribes, Rosa, Rubus* and *Syringa.*

In comparison, 4 kg/ha of simazine gave better weed control than chlorthiamid and dichlobenil in dosages of 3 kg/ha, but completely killed *Syringa reflexa.* Linuron in dosage of 4 kg/ha gave variable results and was not satisfactory as a pre-emergence treatment. It caused depressions in growth of *Acer ginnala, Rosa rugosa* and *Caragana arborescens,* and leaf chlorosis in older plants of *Spiraea* × *bumalda* 'Froebelii' when applied during bud breaking.

Index words: decidious nursery plants, herbicides.

INTRODUCTION

Since the mid-1960's only three residual herbicides, simazine, atrazine and linuron have been allowed in Finland for the control of weeds in ornamental nurseries. Of these, atrazine has been allowed in coniferous nurseries only. Nursery growers have adopted simazine for a wider use, while treatment with linuron has been comparatively rare.

Simazine was present in nursery experiments for the first time in 1960—62 (MUKULA 1962). One-year-old apple, raspberry, gooseberry and currant plants then tolerated 4 and 8 kg/ha of herbicide without injury. Most of the ornamental plants tested in 1964 and in 1965 endured the same doses of simazine and 2—4 kg/ha of linuron (LALLUKKA 1966).

Numerous results of foreign experiments on the resistance of woody crops to simazine have been published during the last twenty years. More extensive resistance lists have been made by, among others, GEIGY 1959, AHRENS 1961, FRYER and MAKEPEACE 1972 and ZSCHAU et al. 1974.

Only a few times is the use of linuron in nursery cultivation mentioned (GROWER 1965, BAKKENDRUP-HANSEN 1970, KOCH 1970, MICHEL 1970 and VAN DE LAAR 1970). Besides Finland, linuron is officially accepted in Germany and Denmark, at least, for use in nurseries raising woody crops.

Other residual herbicides can also be used, with certain restrictions. The best known of these at present are chlorthiamid and dichlobenil, which are closely related to each other (BEYNON et al. 1966). Information on the herbidical effects of dichlobenil are found from the beginning of the 1960's (KOOPMAN and DAAMS 1960, BARNSLEY and ROSCHER 1961, MASSINI 1961). Chlorthiamid has not been known as long as dichlobenil (ANON. 1964).

In addition to experiments conducted by commercial enterprises manufacturing these chemicals, KETTNER and HIRSCH (1969, 1970) in Germany and VAN DE LAAR (1967, 1968) in Holland have conducted extensive experiments on the suitability of these herbicides for nursery use. They have noted that they injure many young crops. Therefore, there have been reservations in recommending their use.

FRYER and MAKEPEACE (1972) have also made tentative recommendations. According to them in doses of 5,88—9,24 kg/ha dichlobenil is suitable for use in nurseries of tolerant trees and bushes. Their tolerance list for doses of 6,72 kg/ha in crops over two years old is not very comprehensive. There are, however, only a few species in the list which are said to be susceptible to this herbicide. The doses in question are considered sufficient to kill all annual and some perennial weeds.

The effect and behaviour of chlorthiamid and dichlobenil in the soil have been clarified by many reseachers, among others, BARNSLEY and ROSCHER (1961), MASSINI (1961), BEYNON et al. (1966), BEYNON and WRIGHT (1968), SHEETS et al. (1968). In the soil chlorthiamid very quickly turns into dichlobenil. Dichlobenil then dissolves into a certain known substance and other less known substances, which can penetrate deep into the soil and do not have any pronounced herbicidal activity.

In the experiments described here, the purpose has been to clarify the suitability of chlorthiamid and dichlobenil for use under Finnish conditions. As many decidious woody ornamental plants as possible were included in the tests. In some trials simazine and linuron were used for comparison, because earlier trials with these substances have not been extensive.

MATERIAL AND METHODS

Four experiments were carried out in the years of 1968—1972. The site of the experiments was the Hankkija commercial nursery in Lieto, Southwest Finland (60°34' N). The nursery planted the species to be tested. The material was 1—3 years old when planted in the autumn, and consisted of cuttings or seedlings not transplanted before.

The test crops were mainly shrubs. Besides these, some varieties of berry and fruit crops were studied. Only a few species were present in two trials. The species in each trial were as follows:

Trial I (1968—1970)

Berberis thunbergii DC.
Caragana arborescens Lam.
Cornus alba L. 'Elegantissima'
Cotoneaster integerrimus Medl.

Crataegus intricata Lge.
Euonymus nanus M.B.
Ligustrina amurensis japonica Maxim.
Ligustrum vulgare L.
Lonicera tatarica L.
Philadelphus L. sp.
Physocarpus opulifolius (L.) Maxim.
Potentilla fruticosa L.
Spiraea trichocarpa Nak.
Rubus L. 'Asker'
Ribes L. 'Brödtorp'
Ribes L. 'Lepaan punainen'
Ribes L. 'Punainen hollantilainen'

Trial II (1969—1971)

Amelanchier spicata Lam.
Berberis thunbergii DC.
Berb. thunb. DC. *atropurpurea* Chen.
Chaenomeles japonica (Thunb.) Lindl.
Cornus alba L.
Cotoneaster lucidus Schlecht
Crataegus intricata Lge.
Lonicera tatarica L.
Mahonia aquifolium (Pursh) Nutt.
Rosa pimpinellifolia L.
Sorbus aucuparia L.
Spiraea × *bumalda* Burv. 'Froebelii'
Malus Mill. 'Bittenfelder'
Pyrus communis L.
Ribes L. 'Brödtorp'
Ribes L. 'Lepaan punainen'

Trial III (1970)

Spiraea × *bumalda* Burvenich 'Froebelii'

Trial IV (1970—1972)

Acer ginnala Maxim.
Caragana arborescens Lam.
Rosa rugosa Thunb.
Syringa reflexa Schneid.

The experiments were conducted according to a randomised block plan (Cochran and Cox 1966). The blocks had to be situated one after another because the plants were in beds. There were 4—5 replications of the herbicide treatments. Apart from one (*Amelanchier* in trial II), there were no replications of the nursery crops. In trials I—III the number of plants per plot varied between 5 and 8, and the plot area was 2,5 m^2. There were 30 plants in trial IV and the area was 5,0 m^2.

In the first trial only chlorthiamid was studied. There were three dosages, 3, 6 and 9 kg/ha, and two treatment periods, autumn and spring. On the basis of the results of this preliminary test the highest dosage was excluded in the following trial. A more accurate test of the effect of 6 kg/ha on weeds was required and it was also wished to clarify the resistance of new nursery species. Dichlobenil was included in a dosage of 3,4 kg/ha in trial II. Comparison between autumn and spring treatments was continued.

In the spring of 1970 a separate trial on two-year-old *Spiraea* × *bumalda* 'Froebelii' plantings was established (trial III). More accurate testing of this species was required because earlier *Spiraea* × *bumalda*-hybrids had proved susceptible to simazine, chlorthiamid and dichlobenil (Schmadlak et al. 1960, Kettner and Hirsch 1969, Zschau et al. 1974). This test as well as the last trial in 1970—1972 (trial IV) included simazine and linuron in addition to chlorthiamid and dichlobenil. The doses of simazine and linuron were 4 kg/ha, and they were applied only in the spring.

The treatments were applied after autumn planting and in the following spring before growth started. The application dates were:

In trial I	November 29 1968 and May 8 1969
In trial II	November 11 1969 and May 9 1970
In trial III	May 12 1970
In trial IV	November 24 1970 and April 28 1971

Chlorthiamid and dichlobenil were given in the form of granules which had been mixed with a small quantity of sand to facilitate spreading. Simazine and linuron were sprayed on, using 4 litres of water per 100 m^2.

The soil in all the trials was finesand. The texture, humus content and pH varied, as follows:

	Particle size distribution (%)					Humus	pH
	Clay	Silt	Finesand	Sand	Gravel	%	
Trial I	10	12	66	9	3	4,3	4,2
Trial II	18	16	59	6	1	4,1	5,5
Trial III	12	8	75	3	2	2,7	6,4
Trial IV	10	5	43	39	3	4,6	6,1

The cultivated plants and the weeds were observed twice during each growing season, in early June and in July-August. In addition to the treatment year, observations were made during the following summer on the after-effects of herbicides. In trials II—IV the weeds were counted by species when they were removed. In these trials besides observing the growth of cultivated plants the ones that had died during the trial period were also noted.

The scale of assessment was 0—10 (changed into 0—100 in the results). For weeds 0 = completely clear of weeds, 10 = soil throughout covered by weeds. The scale includes a combined assessment on the coverage and growth of weeds. For the cultivated crops, 0 = completely dead, 10 = a plant in the most advanced stage of growth considering the circumstances, and undamaged. Visible symptoms were noted throughout the whole summer. The black currant seedlings under the bushes in trial I were kept under observation.

Weather data for 1968—1971 have been taken from the official observations of Turku Airport (ANON. 1968, 1969, 1970 and 1971). The observation site is situated about 11 kilometres from the experiment areas. Fig. 1 shows the mean temperatures and total precipitation by pentadays between April and October over the period of three years. The observations on weather conditions on the days and hours treatments were applied are made by those conducting the trials.

RESULTS

The number of weeds in trials I—III was small, while in trial IV they were numerous. Besides annual species, perennial weeds occurred. There were no great differences in the weed species between the trials.

Weather conditions varied from one year to another, especially during treatment periods in spring. In autumn the applications were made so late that in all cases the weather was cool and humid. These conditions were thought to be favourable for the effects of herbicides.

In the spring of 1969 rain fell after the applications and the mean temperature in May was lower than normal (Fig. 1) (ANON. 1969). In April of 1970 the spring humidity was so high that water lay on the soil surface for about a week in trial II. About the end of April a rainless, warm period set in. At the time the applications were made the soil surface had finally dried. The dry weather continued until the end of June. Total precipitation in May-June was only 22 millimetres (ANON. 1970). Only after abundant rain at beginning of July did the weeds and cultivated plants actually start to grow.

The spring treatments in trial IV (1971) were applied earlier than in the foregoing trials. The application day and a few ; after it were cool and rainy. Gradually weather changed to dry and sunny. Prepi ition was low in May.

Trial I. Weeds

Annual weeds occurring in the untreated areas were: *Alopecurus myosuroides* Huds., *Capsella bursa-pastoris* (L.) Cyrillo, *Chenopodium album* L., *Epilobium montanum* L., *Matricaria matricarioides* (Less.) Porter, *Polygonum aviculare* L., *Spergula arvensis* L., *Stellaria media* (L.) Scop. and *Viola arvensis* Murr.. The perennial species were: *Agropyron repens* (L.) Beauv., *Cirsium arvense* (L.) Scop., *Rumex acetosella* L., *Sonchus arvensis* L., *Taraxacum* Web. sp. and *Trifolium pratense* L.. The proportion of perennial weeds was small, and they generally occurred in groups. In the untreated plots full coverage was achieved only during the second growing season (Fig. 2).

In the assessment made at the end of July it could be noted that all the chlorthiamid treatments had yielded good weed control. After the autumn treatments, the plots were

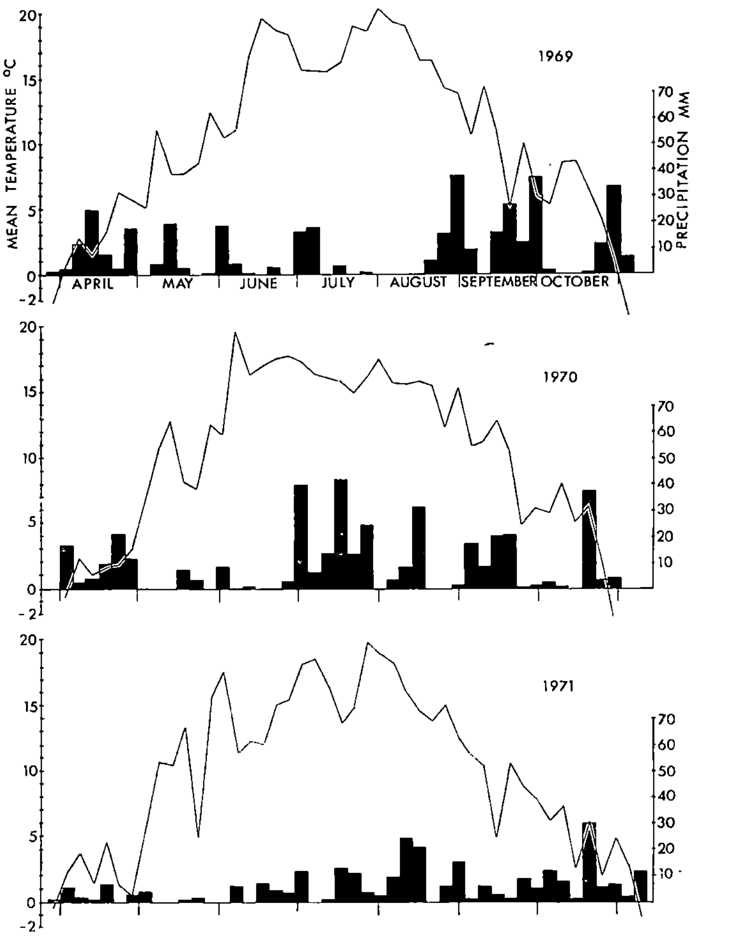

Fig. 1. Mean temperature and precipitation totals by pentadys between April and October, 1969—1971, at Turku Airport.

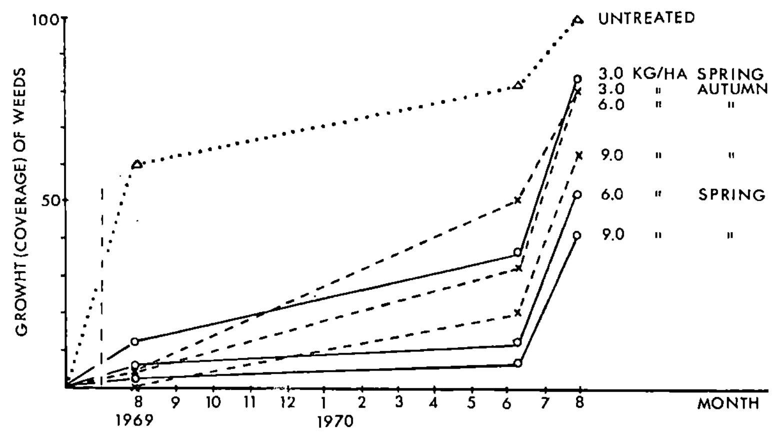

Fig. 2. Sensitivity of weeds occurring in trial I to chlorthiamid with different dosages and application times. Applications November 29, 1968 and May 8, 1969. Observations of primary effect July 29, 1969, of residual effect June 10 and July 29, 1970.

practically clear of weeds. Of the spring treatments, the lowest dose, 3 kg/ha, had somewhat less effect on *Capsella, Epilobium, Polygonum* and *Trifolium* than other treatments.

The areas receiving autumn treatments developed a new weed cover quicker than those treated in spring (Fig. 2). The high doses, 6 and 9 kg/ha, given in spring had good residual effects, even at the end of the growing season. *Epilobium, Capsella, Cirsium* and *Rumex* were the dominant species among the regrowth.

Black currant seedlings occurred most frequently in the areas that were untreated or treated with the lowest dose of chlorthiamid. However, 6 and 9 kg/ha did not restrict them much.

Trial I. Cultivated plants

The average tolerance of cultivated plants over the two-year period is shown in Table I. The spring treatment was somewhat safer than the autumn treatment, but there was no great difference between the doses. Only when studying a tolerance between species and varieties can a more considerable variation be seen between the doses and periods.

The damage to plants consisted mainly of disturbances in growth. No visible chlorosis symptoms were observed. 6 kg/ha injured the same plants as 9 kg/ha but caused less damage. *Lonicera tatarica* and *Cornus alba* were the only species damaged by both autumn and spring treatments at higher dosages. The poor original condition of *Lonicera* may have contributed to its sensitiveness.

In addition, the autumn treatments caused serious injuries in species like *Berberis thunbergii* and *Potentilla fruticosa. Berberis* was partly alive, but weak in growth. *Potentilla* was completely killed during the second growing season. The lowest dose of chlorthiamid, 3 kg/ha, had a negative influence only on the growth and development of *Potentilla.* The spring treated plants were unaffected. *Spiraea trichocarpa* was in bad condition after the second winter but recived during the following summer.

Caragana arborescens, Crataegus intricata and *Philadelphus* sp. showed good tolerance to chlorthiamid. As with other ornamental crops, *Euonymus nanus, Ligustrina amurensis japonica, Physocarpus opulifolius* and *Cotoneaster integerrimus,* showed a barely noticeable decrease in growth occurred after high doses.

Plants of raspberry, gooseberry and currant varieties, although in a weak condition after planting, stood up to all herbicide treatments well. Raspberry and black currant even seemed to become more vigorous after the treatment.

Table 1. Primary and secondary influence of chlorthiamid in autumn and spring treatment on the growth of nursery crops (17 species) in trial 1. Observations July 29, 1969 and 1970, 0 = completely dead, 100 = best growth and without damage.

Treatment period	Dose kg/ha	Average growth of crops 0–100 1969	Rel.	1970	Rel.
Autumn	3,0	71,7	98	78,2	116
	6,0	69,7	96	64,1	95
	9,0	68,2	94	64,1	95
Spring	3,0	72,1	99	81,8	121
	6,0	70,0	96	78,2	116
	9,0	67,9	94	75,0	111
Untreated	–	72,6	100	67,4	100

Trials II and III. Weeds

The annual weeds in trial II were mainly the same as those in trial I. *Epilobium montanum* was absent and *Poa annua* L. was a newcomer. There were very few perennial species. The main weeds in trial III were, as follows, in order of abundance: *Chenopodium album, Capsella bursa-pastoris, Polygonum aviculare, Senecio vulgaris* L. and *Stellaria media.* This trial contained the smallest number of weeds.

Spring treatment of weeds with chlorthiamid was clearly less effective than autumn treatment. With dichlobenil there were only small differences between the application dates. In spring 3 kg/ha of chlorthiamid and 3,4 kg/ha of dichlobenil yielded about the same results. A higher dose of chlorthiamid, 6 kg/ha, was a little more effective than a lower dose, 3 kg/ha.

Table 2 shows the influence of herbicides on the most common weeds during the first growing season. Chlorthiamid and dichlo-

Table 2. Influence of chlorthiamid and dichlobenil on different weed species and total number of weeds in trial II. Applications November 11, 1969 and May 9, 1970, counts August 13, 1970 (number per m^2).

Treatment period	Un-treated	Autumn			Spring		
Herbicide		Chlorthiamid		Dichlobenil	Chlorthiamid		Dichlobenil
Dose kg/ha		3,0	6,0	3,4	3,0	6,0	3,4
Capsella bursa-pastoris (L.) Cyrillo	47,6	6,6	2,0	22,1	29,9	20,3	31,2
Matricaria matricarioides (Less.) Porter	43,2	0,1	0,0	0,3	1,4	0,7	5,4
Viola arvensis Murr.	16,5	2,0	0,4	5,5	7,6	5,0	3,8
Stellarianmedia (L.) Scop.	14,0	1,0	0,3	2,8	1,4	1,1	2,1
Polygonum aviculare L.	2,3	0,2	0,0	0,4	0,6	0,7	0,5
Other species	22,4	0,9	0,1	1,0	1,4	0,2	3,4
Total number	146,0	10,8	2,8	32,1	42,3	35,5	46,4

benil were not sufficiently effective on *Capsella bursa-pastoris.* This weed was already partially germinated at the time of the spring application. The individuals that survived treatment shed their seeds during the summer. In the following growing season the species occurred everywhere in the areas treated.

In the untreated areas *Matricaria matricarioides* occurred in almost the same quantities as *Capsella.* It was completely destroyed with herbicides. It was also partly germinated at the time the herbicides were applied. Species which germinate later, *Viola arvensis* and *Stellaria media,* occurred to some extent in the mid-August counting.

In trial III simazine yielded the best result as far as weeds are concerned (Table 3). The effect of linuron and chlorthiamid was the same, that of dichlobenil somewhat weaker. Compared with the lower dose, a higher dose of chlorthiamid did not increase the effect noticeably. At the treatment stage the weeds *Capsella* and *Polygonum* had already germinated. Only simazine had any effect on them under dry conditions.

Table 3. Total number and weight of weeds after spring treatment with different herbicides. Applied May 12, 1970, counted and weighed August 8, 1970.

Treatment		Weeds			
Herbicide	Dose kg/ha	Number /m^2	Rel.	Weight g/m^2	Rel.
Chlorthiamid	3,0	11	24	100	23
	6,0	7	15	95	22
Dichlobenil	3,4	17	37	130	30
Simazine	4,0	2	4	10	2
Linuron	4,0	9	20	118	27
Untreated	—	46	100	440	100

Trials II and III. Cultivated plants

In the spring of 1970 growth started poorly due to the spring drought. Plants also died in untreated plots. The remaining plants started to revive and grow only after the July rains.

Judging from mortality rate (Table 4) and growth vigour, chlorthiamid was more dangerous to cultivated plants as an autumn treatment than as a spring treatment. Under the first summer the situation was reversed with dichlobenil, but this was not so later.

Representatives of *Amelanchier, Rosa, Ribes* and *Sorbus* generas proved most resistant. *Malus* 'Bittenfelder', *Pyrus communis* and *Lonicera tatarica* showed minor but not clear signs of susceptibility. In *Crataegus intricata* and *Sorbus aucuparia,* that had received 3 and 6 kg/ha chlorthiamid, leaf-margin chlorosis was noted in the second year. No growth disturbances occurred.

Nor all *Berberis thunbergii atropurpurea* survived autumn treatment with chlorthiamid or both treatments with dichlobenil. The main form of this species was somewhat more tolerant than this cultivated form. Chlorthiamid also damaged *Spiraea* × *bumalda* 'Froebelii', *Cornus alba* and *Mahonia aquifolium* as an autumn treatment. *Cotoneaster lucidus* was weak in all plots during the first summer. Other species showed no noticeable marks of damage, but neither were they vigorous. In some cases dichlobenil caused less growth depression than chlorthiamid (*Cornus* and *Malus*).

In *Spiraea* × *bumalda*-hybrid (Trial III) chlorthiamid and dichlobenil caused a decrease in growth and premature reddening in the

Table 4. Susceptibility of certain nursery crops to chlorthiamid and dichlobenil, on the basis of plant mortality. Number of dead plants, 1 = August 13, 1970, 2 = July 23, 1971.

Treatment period	Un-treated		Autumn						Spring						Total number /all treat-ments
Herbicide			Chlorthiamid				Dichlobenil		Chlorthiamid				Dichlobenil		
Dose kg/ha			3,0		6,0		3,4		3,0		6,0		3,4		
Observation date	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
Amelanchier spicata Lam.	0	3	0	0	1	2	1	0	0	0	0	0	0	2	6
Berberis thunbergii Dc.	0	1	0	5	1	5	0	2	0	3	0	5	0	2	20
Berb. thunb. DC. *atropurpurea* Chen.	1	5	1	7	0	7	0	7	0	3	0	3	0	6	34
Chaenomales japonica (Thunb.) Lindl.	3	3	1	0	1	1	1	0	3	3	3	4	3	3	23
Cornus alba L.	4	0	1	0	3	3	0	1	0	2	3	1	1	2	17
Cotoneaster lucidus Schlecht	4	0	5	0	5	0	3	1	2	2	5	0	5	0	28
Crataegus intricata Lge.	0	3	1	0	0	1	0	1	0	0	0	0	1	0	4
Lonicera tatarica L.	0	0	0	1	0	0	0	1	0	0	0	2	0	1	5
Mahonia aquifolium (Pursh) Nutt.	0	0	2	3	1	5	3	2	0	0	0	0	0	2	18
Malus Mill. 'Bittenfelder'	1	0	3	0	2	0	0	0	2	0	4	1	2	0	14
Pyrus communis L.	0	0	0	2	1	0	0	1	0	1	0	1	0	0	6
Ribes L. 'Brödtorp'	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Ribes L. 'Lepaan punainen'	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Rosa pimpinellifolia L.	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
Sorbus aucuparia L.	0	0	0	0	1	0	0	0	0	1	0	1	0	0	3
Spiraea × bumalda Burvenich'Froebellii'	0	4	0	4	0	6	0	3	1	0	1	0	0	1	16
Total number	13	19	14	22	16	32	8	20	8	16	16	18	12	19	

colour of the foliage. The influence of linuron was apparent in interveinal chlorosis in leaves in late summer. *Spiraea* tolerated simazine best. The plants were at the opening-bud stage when the applications were made.

Trial IV. Weeds

In the experimental area there was considerably more *Epilobium montanum* than other weeds. The chlorthiamid autumn treatment and the

Table 5. Effect of chlorthiamid, dichlobenil, simazine and linuron on annual and perennial weeds. Autumn application November 24, 1970, spring application April 28, 1971. Weeds counted July 22, 1971 (number per m^2).

Treatment period		Autumn		Spring			
Herbicide	Un-treated	Chlor-thiamid	Dichlo-benil	Chlor-thiamid	Dichlo-benil	Simazine	Linuron
Dose kg/ha		3,0	3,0	3,0	3,0	4,0	4,0
Annual weeds							
Epilobium montanum L.	367,0	2,5	33,5	35,0	13,0	0,0	144,5
Poa annua L.	20,5	2,5	25,5	6,0	5,5	0,0	35,5
Senecio vulgaris L.	20,3	2,5	4,5	2,5	0,0	2,5	16,0
Matricaria matricarioides (Less.) Porter	15,3	1,0	0,0	0,5	1,0	1,5	19,5
Matricaria inodora L.	9,8	0,0	0,0	1,0	0,0	0,0	0,0
Capsella bursa-pastoris (L.) Cyrillo	2,5	4,0	1,5	0,5	4,0	0,0	1,0
Stellaria media (L.) Scop.	0,3	2,5	0,0	1,5	1,5	2,5	1,0
Viola arvensis Murr.	0,3	0,0	1,5	2,0	5,0	0,5	0,0
Galeopsis speciosa Mill.	0,0	2,0	0,0	0,0	0,0	0,5	0,0
Erysimum cheiranthoides L.	0,0	1,0	0,0	0,0	0,0	0,0	1,0
Other species	0,5	0,0	0,0	0,5	1,5	0,5	1,0
Total number	436,5	18,0	66,5	49,5	31,5	8,0	219,5
Perennial weeds							
Cirsium arvense (L.) Scop.	11,3	45,5	52,5	30,0	41,5	42,5	4,5
Taraxacum Web. sp.	6,3	0,5	0,0	1,5	1,5	6,5	2,0
Rumex acetosella L.	2,8	0,5	1,0	3,0	2,0	1,0	1,0
Other species	0,0	0,0	0,0	1,5	2,5	0,0	3,5
Total number	20,4	46,5	53,5	36,0	47,5	50,0	11,0

simazine spring treatment were the only ones that were effective against it. Chlorthiamid generally proved to be more effective in autumn than in spring. Dichlobenil had no effect on *Poa annua* in autumn and its effect on *Epilobium* was poorer then than in spring. The spring treatments of chlorthiamid and dichlobenil had an equally good total effect with the exception of *Epilobium* (Table 5).

Simazine destroyed all annual weeds well, but linuron was very ineffective. On the other hand linuron had a destructive influence on thistle which tended to spread in other trial plots. Other weed species that occurred in the area and the effect of treatments on them are given in Table 5. Herbicides excluding linuron had an after-effect on the germination of annual weeds in the second summer. The weeds present had been removed at the end of July in the first season.

Trial IV. Cultivated plants

The initial plant material in this trial was uneven. *Rosa rugosa* and *Syringa reflexa* were in poorer condition than *Acer ginnala* and *Caragana arborescens.* Most of the *Rosa* plants died quickly. The individuals that survived began to grow well later apart from those which had been treated with linuron (Fig. 3). Linuron also weakened *Acer* and *Caragana. Syringa* was the only species that could take such high a dose of linuron (4 kg/ha).

Simazine was tolerated by all other species except *Syringa,* which was completely dead after the first season. Chlorthiamid and dichlobenil proved safe to all ornamental plants in this trial (Fig. 3). As a result of using dichlobenil, *Acer* and *Caragana* grow more vigorously and steadily than after other treatments.

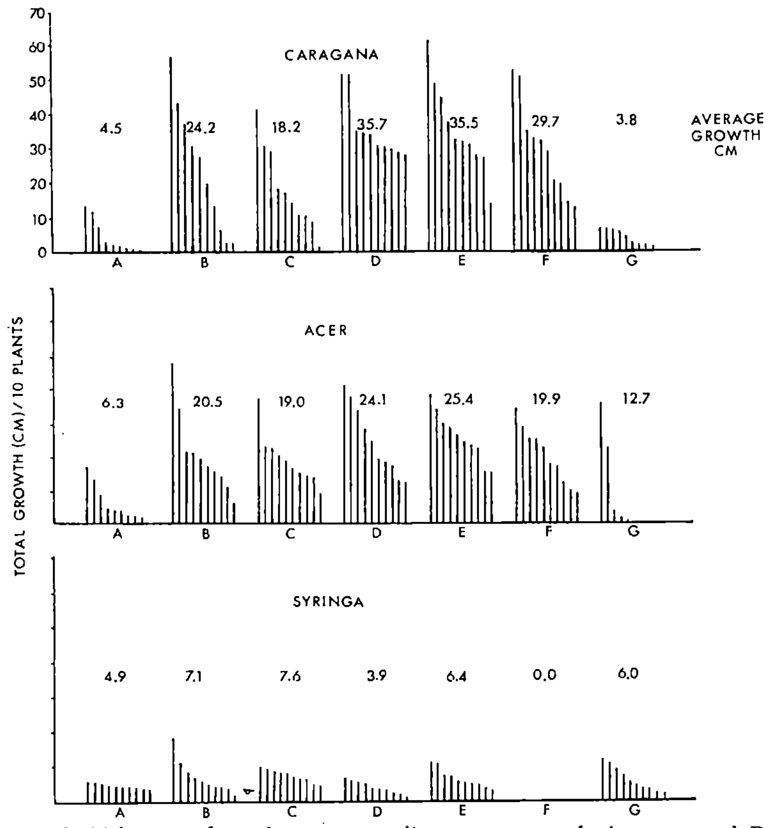

Fig. 3. Tolerance of woody crops according to year growth. A = untreated, B = chlorthiamid 3 kg/ha in autumn (November 24, 1970), C = chlorthiamid 3 kg/ha in spring (April 28, 1971), D = dichlobenil 3 kg/ha in autumn, E = dichlobenil 3 kg/ha in spring, F = simazine 4 kg/ha in spring and G = linuron 4 kg/ha in spring. Measurements September 3, 1971.

DISCUSSION

On the basis of the results it can be concluded that the treatment period and weather conditions at the time of treatment and after it had a very pronounced influence on weed control and crop tolerance.

In the unusually dry and warm spring of 1970 the effect of chlorthiamid and dichlobenil was clearly poorer than in other springs in the experiment. The drought probably caused vapour losses in the herbicides (HOROWITZ 1966). Dichlobenil, in particular, is known to volatilize under high temperatures, high soil moisture levels and low air humidity, or circumstances corresponding to 'drying conditions' (DAAMS 1965, ANON. 1972). In similar but propably cooler conditions dichlobenil is effective on weeds in vapour form (BARNSLEY and ROSCHER 1961, MILLER et al. 1967).

In experiments made by SPENCER-JONES and WILSON (1968) dichlobenil gave better control of quack grass and other weeds in the autumn than in the spring. The firm manufacturing this herbicide has estimated that it would be better as an autumn treatment in northern countries, where the spring season is usually too short (ANON. 1972). The present studies did not confirm this, because some common weed species were more resistant to dichlobenil in autumn than in spring. Perhaps the precipitation in autumn and winter was too high for dichlobenil.

Chlorthiamid has a remarkable biological activity when applied to germinating seeds (ANON. 1964). It needs rain on top of the application (VAN DE LAAR 1968). It penetrates deeper into the soil than dichlobenil (NÖLLE 1967) and has proved more effective than dichlobenil (VAN DE LAAR 1967). Its properties are evident, when studying the results. The more serious damage sustained by some cultivated plants after autumn treatments than after spring treatments indicate that chlorthiamid leaches into deeper layers.

In both herbicides a dosage of 3 kg/ha gave good but not total weed control under favourable conditions. If the number of weeds is great, this rate is not sufficient. According to the other experience a rate of 4 kg/ha gives good control of annual weeds and somewhat suppresses perennials (ANON. 1964, SANFORD 1964). The higher dosage cannot be recommended because of intolerance in cultivated plants.

According to FRYER and MAKEPEACE (1972) also, *Capsella, Poa* and *Polygonum* generas are resistant to chlorthiamid and dichlobenil, but *Epilobium* is sensitive. *Poa* recovers in late summer and the perennials increase the following season (HIRSCH 1968) because only the parts uncovered by soil, of *Cirsium,* for example, die after herbicide applications (KETTNER and HIRSCH 1969).

No definite conclusions can be drawn on the real tolerance of cultivated plants on the basis of one or two experiments. Generally speaking, the crops seemed to be fairly resistant to chlorthiamid and dichlobenil. The small, weakly growing plants were not, however, as resistant as the stronger ones. Some woody species, and especially young plants of these types, have shallow root-systems. They may then absorb more herbicide than deep-rooted crops, and thus be sensitive (KOCH 1970).

About a half of the species which seemed to be resistant in this experiment belongs to the *Rosaceae* families. KETTNER and HIRSCH (1969) also found that this families were resistant to chlorthiamid and dichlobenil. *Spiraea* and *Potentilla* are an exception. They were especially susceptible to autumn treatments. Identical to the results of SANFORD (1964) berry varieties were noted to tolerate big dosages of chlorthiamid. However, ornamental species of *Ribes* generas showed symptoms of toxicity in German experiments (KETTNER and HIRSCH 1969 and 1970).

Spiraea, especially *bumalda*-hybrids, have been reported to be sensitive by many workers, as mentioned before. This crop is sensitive to nearly all residual herbicides. *Cornus, Potentilla* and *Berberis* have tolerated chlorthiamid and dichlobenil badly in various experiments (VAN DE LAAR 1967, KETTNER and HIRSCH 1969, ANON. 1972). All the species of these generas have shallow root-systems. The extreme sensitivity to simazine of *Syringa* is known from other connections (SCHMADLAK et al. 1960, LODE 1969, FRYER and MAKEPEACE 1972). Only *Spiraea* and *Caragana* should habe been susceptible among the species that received linuron (GROWER 1965, LALLUKKA 1966, MICHEL 1970). The noticeable symptoms of toxicity were probably due to too large doses of this herbicide.

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SELOSTUS

Maavaikutteisten rikkakasvihävitteiden käytöstä taimistokasveilla

ANNELI KARHINIEMI

Maatalouden tutkimuskeskus[1]

Vuosien 1968—1972 aikana selvitettiin klortiamidin ja diklobeniilin soveltuvuutta taimistojen rikkakasvihävitteiksi. Neljästä kokeesta kahdessa olivat lisäksi mukana taimistokäytössä entuudestaan tunnetut aineet simatsiini ja linuroni. Käsittelyt suoritettiin viljelykasvien syysistutuksen jälkeen syksyllä tai seuraavana keväänä. Kokeissa testattiin kaikkiaan 32 taimistokasvin kestävyyttä. Näistä kasveista oli 26 koristekasvilajeja, 4 marjakasvilajikkeita, 1 omenapuun perusrunko ja 1 tavallinen päärynä.

Klortiamidin vaikutusta ja tehoa selvitettiin laajemmin kuin diklobeniilin vaikutusta. Nämä sukulaisaineet käyttäytyivät kuitenkin monessa suhteessa samalla tavalla. Nuorten kasvien taimistossa osoittautui 9 kg/ha klortiamidia liian suureksi käyttömääräksi. Jo määrillä 3 ja 6 saatiin suotuisissa oloissa hyvä, joskaan ei täydellinen teho yksivuotisiin rikkakasveihin. Pienimmän määrän, 3 kg/ha vaikutus näkyi noin kasvukauden ajan, suurimman määrän, 9 kg/ha lähes kaksi kasvukautta.

Yksivuotisista rikkakasveista olivat kestävimpiä lutukka (*Capsella bursa-pastoris*), lehtohorsma (*Epilobium montanum*) ja kylänurmikka (*Poa annua*). Diklobeniili tehosi lehtohorsmaan ja kylänurmikkaan paremmin kevät- kuin syyskäsittelynä. Klortiamidi tehosi lähes kaikkiin rikkakasveihin paremmin syksyllä kuin keväällä. Sen kevätkäsittelystä jäi jäljelle pääasiassa lutukkaa ja lehtohorsmaa. Monivuotiset ja jo taimettuneet rikkakasvit kestivät kummankin hävitteen pienet käyttömäärät hyvin. Monivuotisista oli täysin kestävä pelto-ohdake (*Cirsium arvense*). Keväällä oli aikainen, huhtikuun lopussa suoritettu käsittely tehokkaampi kuin pari viikkoa myöhemmin suoritettu käsittely. Tosin nämä tulokset ovat eri vuosilta.

Turvallisin käyttömäärä viljelykasvien kannalta oli 3 kg/ha. Tämäkin vioitti syksyllä annettuna arimpia lajeja, joiksi osoittautuivat happomarja (*Berberis thunbergii*), kanukka (*Cornus alba*), mahonia (*Mahonia aquifolium*), hanhikki (*Potentilla fruticosa*) ja angervo (*Spiraea* x *bumalda* 'Froebelii'). Diklobeniili ei vahingoittanut syyskäsittelynä näitä kasveja niin paljon kuin klortiamidi, jonka tiedetään painuvan syvemmälle maahan. Kevätkäsittelyjen jälkeen vioittuivat mainittavassa määrin ainoastaan happomarja määrästä 6 kg/ha klortiamidia sekä happomarja ja ruusukvitteni (*Chaenomeles japonica*) määrästä 3,4 kg/ha diklobeniilia.

Marjakasvien taimet olivat kestäviä, hedelmäpuiden taimet niitä hiukan arempia. Koristekasveista osoittivat huomattavaa kestävyyttä seuraavat lajit: vaahtera (*Acer ginnala*), tuomipihlaja (*Amelanchier spicata*), hernepensas (*Caragana arborescens*), orapihlaja (*Crataegus intricata*), jasmike (*Philadelphus* sp.), ruusu (*Rosa pimpinellifolia*), pihlaja (*Sorbus aucuparia*) ja syreeni (*Syringa reflexa*). Orapihlajan ja tavallisen pihlajan lehdet kellastuivat reunoista klortiamidikäsittelyjen seurauksena, toisena kasvukautena käsittelyistä. Tämä ilmiö näytti kuitenkin kasveille vaarattomalta. Pienikokoiset ja heikkokuntoiset taimet olivat herkempiä hävitteille kuin kookkaat, voimakkaat taimet.

Simatsiini oli klortiamidia ja diklobeniilia tehokkaampi. Sitä käytettiin ainoastaan keväällä määränä 4 kg/ha. Simatsiini vahingoitti mainittavammin ainoastaan syreeniä, jonka kaikki taimet kuolivat ensimmäisen kesän aikana.

Linuroni 4 kg/ha ei antanut riittävää tehoa yksivuotisiin rikkakasveihin, mutta heikensi tuntuvasti ohdaketta, kun ainetta käytettiin aikaisin keväällä. Muutamaa viikkoa myöhäisempi käsittely olisi todennäköisesti tehokkaampi, mutta se vaarantaisi viljelykasveja. Esim. angervossa (*Spiraea* x *bumalda* 'Froebelii') linuroni aiheutti suonivälikloroosia lehtiin, kun käsittely suoritettiin pensaiden silmujen ollessa avautumassa. Heikkokuntoiset vaahteran, ruusun (*Rosa rugosa*) ja hernepensaan taimet vahingoittuivat hiukan linuronikäsittelystä, sen sijaan syreeni kesti käsittelyn hyvin.

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EFFECTS OF PROPAGATION CONDITIONS ON GREENHOUSE TOMATO YIELD

LEA KURKI

KURKI, L. 1977. **Effects of propagation conditions on greenhouse tomato yield.** Ann. Agric. Fenn. 16: 49—56. (Agric. Res. Centre, Inst. Hortic., SF-21500 Piikkiö, Finland.)

Different factors in the propagation of young tomato plants for greenhouse growing at the northern latitudes of 60—65° were tested. The main propagation period was in midwinter. When peat, properly fertilized and watered, was used as the growing substrate, paper, peat and plastic pots and peat blocks with a 5—6 cm diameter and 4—7 cm height were suitable for direct sowing, and similar pots or blocks with the dimensions of 10 × 10 cm for transplanting. The above sizes of the pots nor the material did not have any significant effect on the earliness nor the total of tomato yield.

The combination of a fluorescent tube Floralux 80 W during the seedling stage and a mercury reflector lamp HLRG 400 W afterwards, or a high pressure mercury iodide lamp HPI 400 W alone and a sodium lamp SON 400 W alone increased the early and total yields of tomato which was sown in the middle of December and grown in the photoperiod of 12 or 16 h at temperatures of 17/22°C (night/day). The temperature of the growing substrate depended on the variety, the amount of light and the night/day temperatures. 'Revermun' gave a heavier and earlier yield at the substrate temperature of 15°C, and 'Sonato' at 22°C, when the substrate temperatures of 15, 18 and 22°C were compared at the air temperatures of 17/22°C (night/day). The air temperatures 13/18°C (night/day) decreased and delayed the yields at the substrate temperatures tested. The earliest and heaviest yield with optimal timing was obtained, when the young tomato plants were planted at the stage of development when the first flower was out in the first truss, compared with the two other development stages: 1) the first visible flower cluster with closed buds and 2) the first flower of the second truss out.

Index words: propagation, young tomato plants, pots, substrate, artificial light, photoperiod, stage of development, 'Revermun', 'Sonato'.

INTRODUCTION

In Finland, greenhouse tomatoes are grown at the northern latitudes of 60—65°. The main crop is sown in the middle of December. Young plants are then ready for planting in mid February, when there is enough natural light for photosynthesis. The first tomatoes appear on the market in April. Heating and artificial light increases the propagation costs, but on the other hand the tomato plants have rather a large leaf area and a well — developed root system ready to utilize the optimal growing conditions that prevail from mid February onwards.

It is known that the vigour of the small plants contributes to the early and total yields of tomatoes (Calvert 1959, Lawrence 1963). In some countries it has been noted (Spithost 1969) that a considerable amount of the total tomato yield is lost every year because the young tomato plants have not been properly propagated. This can also be the case in Finland.

The growing of young tomato plants is a specialized commercial production that demands not only the development but also the standardization of growing methods that will produce vigorous and productive young plants suited to the climatic conditions of the Finnish tomato growing areas. Therefore different propagation pots, different sources of artificial light, lengths of the photoperiod, temperatures of the growing substrate and stages of the young plants' development on planting were tested, and their effect on the early and total commercial yields of greenhouse tomato was evaluated.

MATERIALS AND METHODS

The experiments presented here were carried out in greenhouses constructed of aluminium and with glass windows, at the Institute of Horticulture at Piikkiö, Finland. The greenhouse tomato variety 'Revermun' was used in all experiments, and when the temperature of the growing substrate was tested 'Sonato' was also used. Fertilized peat was used as a potting media and growing substrate. The following fertilizers were used: 12 kg/m^3 Dolomite lime (=CaO 52 %, Ca 35 %, Mg 10 %), 1/2 kg/m^3 Compound Super Y-fertlizer for Peat (= N 8 %, P_2O_5 30 %, K_2O 18 %), and 0,15 kg/m^3 of a mixture of trace elements.

Seedpots and transplanting pots used in the experiments, their volume and the number of pots/m^2 are shown in Table 1. The seedpots, transplanting pots of different experiments as well as the sowing, transplanting and planting dates are given in the figures and tables on the results of the experiments in question.

The germination temperature was 23°C and after emergence the soil temperature was 20°C and the air temperatures were 17°C at night and 22°C in daytime. When the temperatures of the growing substrate were tested, they were as shown in Figs. 2—4. Additional artificial light was given from December 20th to Febru-

Table 1. Propagation pots, dimensions, volume and density/m^2.

Type of pot	Diameter cm	Height cm	Volume cm^3	Pots/m^2
PF 306 (Vefi)	6,0	5,0	120	259
PF 310 "	9,0	7,0	567	95
Paper pot Vh 505	5,0	5,0	81	616
Paper pot Vh 608/2	6,0	3,8	88	428
Paper pot Vh 605	6,0	5,0	117	428
Paper pot Vh 608	6,0	7,5	175	428
Paper pot Vh 1010	10,0	10,0	649	154
Peat block 6 × 6	6,0	6,0	216	324
Peat block 10 × 10	10,0	10,0	1000	100
Peat pot FP 23	6,0	6,0	100	330
Peat pot FP 40	10,0	9,0	500	120
Plastic film tubes	20,0	20,0	6280	25

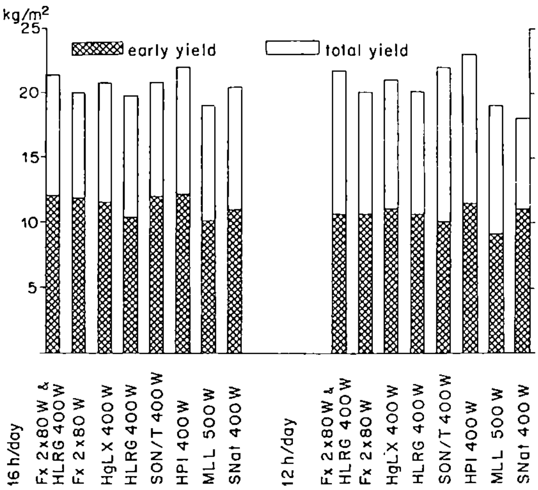

Fig. 1. The influence of additional artificial light and photoperiod on early and marketable yields of greenhouse tomato. 'Revermun', sown in Vh 605 paper pots Dec. 20. transplanted in Vh 1010 paper pots Jan. 10., and planted Febr. 16. Illumination during the period from Dec. 26. to Febr. 15.

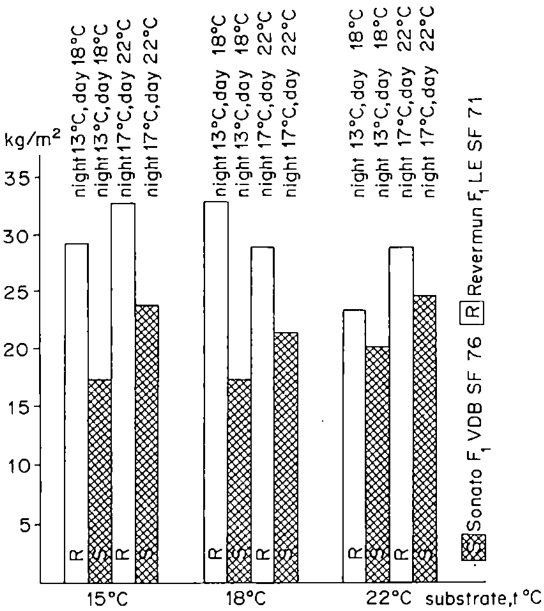

Fig. 2. The marketable yield of greenhouse tomato as affected by the temperature of the growing substrate. Sown Dec. 20. in paper pot Vh 605 transplanted in paper pot Vh 1010 Jan. 15., planted Febr. 15.

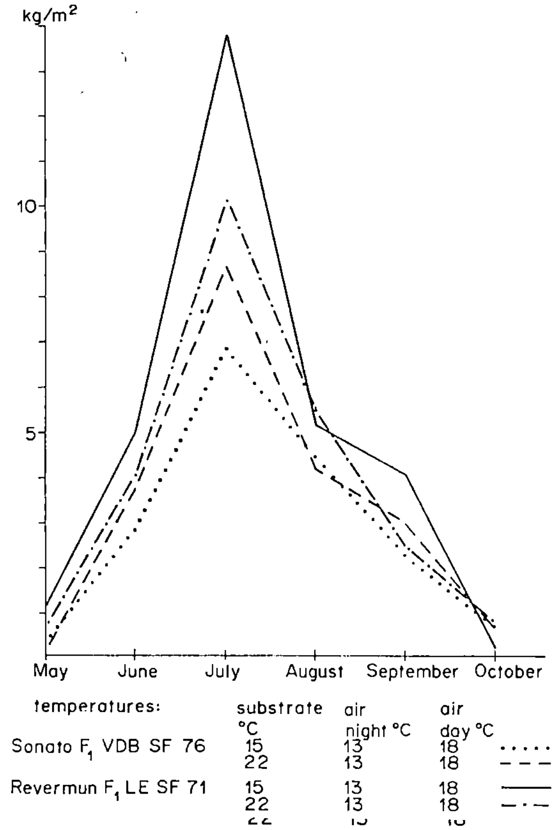

Fig. 3. Timing of the yield of tomato grown from plants propagated at different temperatures of the growing substrate, and at the night and day temperatures of 13/18°C in the air.

ary 15th for 12 hours/day from 8.00 am. with Floralux 80 W fluorescent lamps during the first three weeks and with a mercury high pressure lamp HgLX 400 W after that. The lamps tested and the illumination periods are shown in Fig. 1. Fluorescent lamps were hung 40 cm above the plant tops and mercury high pressure lamps 120 cm. Artificial light was given in 150 W/m^2 which means about 2000 lux under the fluorescent lamps and about 3000 lux under the mercury high pressure lamps.

The young tomato plants were planted in the greenhouse, when the first flower was out in the first cluster. When the effect of the development stage was being tested, two other stages were included as shown in Figs. 5–6.

The greenhouse growing conditions after the transplanting were as follows: day temperature

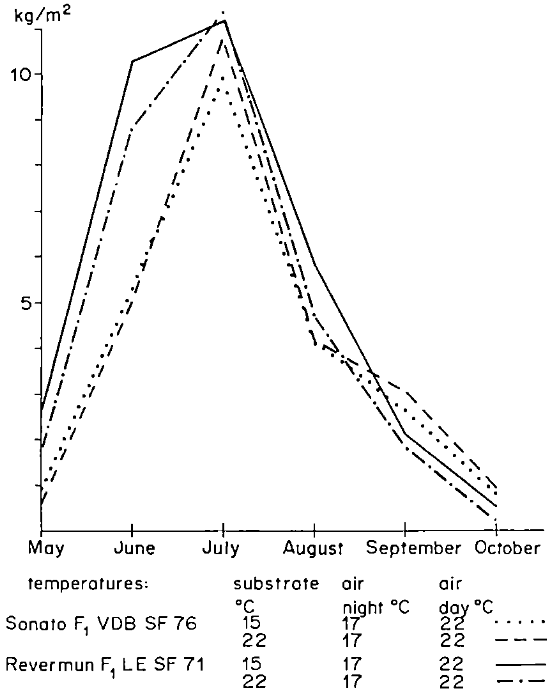

Fig. 4. Timing of the yield of tomato grown from plants propagated at different temperatures of the growing substrate, and at the night and day temperatures of 17/22°C in the air.

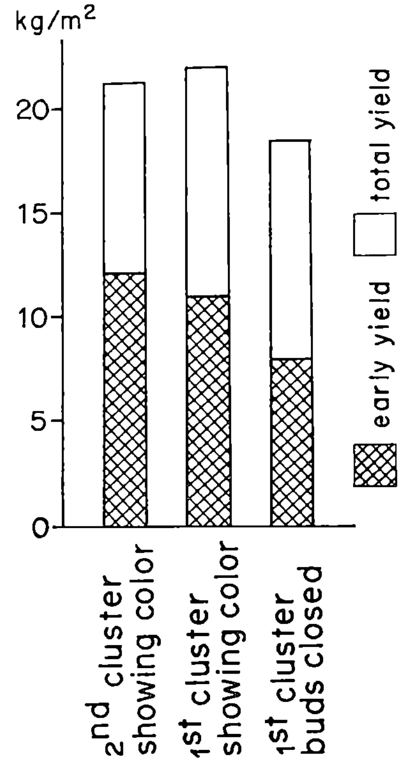

Fig. 5. The influence of the stage of development at planting on the early and total yield of tomato 'Revermun' sown Dec. 20. in paper pot Vh 605, transplanted Jan. 15. in paper pot Vh 1010, planted Febr. 16.

18—22°C, night temperature 16—18°C and substrate temperature 18—20°C. Ventilation was started at 24°C. Relative humidity of the air was kept at 60—70 %. The growing density was 3 plants/m² and the growing substrate was fertilized peat. Additional fertilizers were given after the results of the soil analysis and water was given by drop-watering. A variance analysis was used for the statistical treatment of the results.

RESULTS

Effect of propagation pots on the early and total yield of tomato

The propagation pots used in these experiments are given in Tables 2—3. Pots are described in Table 1. Table 2 shows that the effect of propagation pots on tomato yield is not significant, when peat is used as potting media and the size of the seed pots is about 5 × 5 × 5 cm, and that of the transplant pot is about 10 × 10 × 10 cm (Table 1). This applies particularly to the sowings of mid December at the northern latitudes of 60—65°. When summer and autumn tomato is grown and the sowing takes place under favourable natural light conditions larger pots for transplanting are preferable (Table 3).

However, it can be seen that a seed pot with

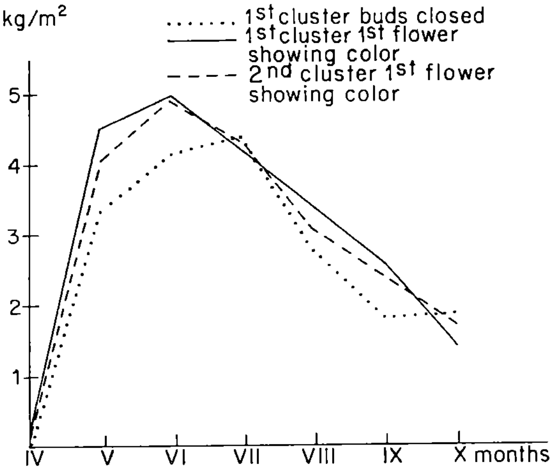

Fig. 6. Influence of the stage of development at planting on timing of tomato yield.

Table 3. Influence of propagation pots on marketable yield of late greenhouse tomato 'Revermun'.

Sowing pot	Transplant pot	Relative marketable yield
Paper pot Vh 605	Paper pot Vh 1010	100
Paper pot Vh 608/2	Paper pot Vh 1010	87
Paper pot Vh 608	Paper pot Vh 1010	100
Plastic pot, net 2"	Plastic pot 5"	100
Peat block 6 × 6 cm	Peat block 10 × 10 cm	102
Peat pot FP 23	Peat pot FP 40	100
Paper pot Vh 605	Plastic tube 20 × 20 cm	116***
Peat block 6 × 6 cm	Plastic tube 20 × 20 cm	119***

Sowing March 10
Transplanting March 26
Planting May 25
Harvesting June 8 — Oct. 15

F-value 24,3
*** = 99,9 % significance

a diameter smaller, and a height lower than 5 cm does decrease the early and total yield. A slight increase in yield is noticeable in December sowing, when peat blocks were used as propagation pots (Table 2).

Additional artificial light and photoperiod

The amount of natural light in mid-winter is scarce (Table 4) in Finland. Artificial light as additional light had a slightly different effect on the yield of tomato due to the amount and quality of the light that the lamp is radiating. Differences in early and total tomato yields, when the young plants were propagated under the lamps indicated in Fig. 1. are shown in the same figure. It can also be seen that, when compared with the photoperiod of 12 hours, the 16 hours photoperiod increased the early and total yield so little that exact calculations of propagation costs has to be made in order to find out which photoperiod is the most profitable.

Table 2. Influence of propagation pots on the marketable early and total yields of greenhouse tomato 'Revermun'

Seed pot	Transplant pot	Relativ yield April—May	Relativ yield April—October
PF 306	PF 310	100	100
Paper pot Vh 505	Paper pot Vh 1010	100	100
Paper pot Vh 608/2	Paper pot Vh 1010	97	98
Paper pot Vh 605	Paper pot Vh 1010	101	100
Paper pot Vh 608	Paper pot Vh 1010	102	101
Peat block 6 × 6 cm	Peat block 10 × 10 cm	105	107
Peat pot FP 23	Peat pot FP 40	101	102
Sown in seed box	Seedling transplanted in plastic pot 10 cm	102	103

Sowing Dec. 20
Transplanting Jan. 7
Planting Febr. 15
N.S.

Table 4. Total radiation at 60° 23' N 33' E in the midwinter.

Month	Mean total radiation outside in 1968—1974 mWh/cm²	Radiation in greenhouses appr. mWh/cm²	Length of day in the beginning — in the end of month h
November	1051	200	8,5—6,5
December	476	80	6,5—6,0
January	773	352	6,0—8,0
February	2408	1033	8,0—10,2

The temperature of the growing substrate

The temperature of the growing substrate seemed to be dependent on the variety and on the night and day temperatures of the air (Fig. 2), as well as on the prevailing amount of light. 'Revermun' gave a heavier and earlier yield at the substrate temperature of 15°C while 'Sonato' preferred a higher substrate temperature when the night/day temperatures were 17/22°C in the air. Lower air temperatures delayed and decreased the tomato yield. The timing of the yield was better in higher air temperatures at both high and low substrate temperatures (Figs. 3—4).

The stage of development on planting

The best early yield was produced by the tomato plants which were planted when the second flower cluster had its first flower out (Fig. 5). The best total yield and also the best economical result was obtained, however, when the young tomato plants were planted in the greenhouse when the first flower in the first truss showed colour. The timing of the yield (Fig. 6) was also best with the plants planted at the first mentioned on these two development stages.

DISCUSSION

The necessity of artificial light and heating during the main propagation period of young greenhouse tomato plants in Finland introduces a demand for the highest possible number of plants from a propagation area. The approximate size of 5 × 5 × 5 cm for the seed pots of tomato has been fixed by a long practice of young tomato plant propagation. The volume of the seed pots at the limits mentioned above does not significantly influence the tomato yield when peat is used as a potting substrate provided that peat is properly watered and fertilized as described by PUUSTJÄRVI (1968). A slight decrease in yield, however, is to be seen when the seed pot is smaller. It has been stated earlier, e.g. by HALLIG and BREDMORE 1971), that large pots give strong tomato plants and heavy yields. Larger pots than those used here would be preferable when a very early and heavy tomato yield is needed as in the case of the December sown tomato in Finland. Transplant pots of the 10 × 10 × 10 cm size tested here seem to be very suitable for various sowing times. The material and volume of the propagation pots in the limits mentioned have no special effect on the yield if the plants are properly cared for. It is more important to choose a potting method suitable for the circumstances of the grower.

At present, many types of lamps are recommended as an artificial light source for photosynthesis. A low-cost mass-produced lamp is of interest to the growers. Therefore also lamps used for ordinary illumination purposes were tested here. Fluorescent lamps (tubes), Floralux for example, will again become popular not only because of their small consumption of energy and the opportunities they offer for many kinds of light qualities, but mainly because of their suitability for growing rooms. The artificial light radiated by Floralux has earlier been found suitable for photosynthesis (KURKI 1965). It is often used for tomatoes during the seedling time before the plants are spaced out, after which high pressure lamps are more convenient. A high pressure mercury iodide lamp HPI and a high pressure sodium lamp SON each have as favourable an effect on tomato yields as the combination of a fluorescent lamp Floralux and a high pressure mercury lamp HLRG.

The temperature of the growing substrate of tomato has been studied among others by BOXALL (1962) who stated that the maximum vegetative growth with tomato is obtained at a substrate temperature of about 24°C. This is also proved by CANHAM (1966). There may be differences with varieties as the present experiments show. The results presented here will give an idea of how to grow 'Sonato' which at present is widely grown in Europe. The fact that 'Revermun' produces good yields also when the substrate temperature is low might have something to do with the soil pathogenes. This, however, is by no means proved by these experiments. It is important to learn that when using higher soil temperatures the temperatures of the air can be lower.

In circumstances where light is the minimum growth factor, there is a possibility that the first flower truss will be aborted when the tomatoes are planted. This can be followed by the abortion of the second truss as the growth becomes vigorous. It is, however, of economic importance to get a good setting in the first flower trusses. In countries that in the winter have more light than Finland, it has been noticed that for tomatoes the best development stage on planting is when the first flower cluster is still in the bud-stage (LAWRENCE 1963). The importance of planting young tomato plants when the first flower cluster is showing colour, i.e. the first flower is out, has been stated by LARGE (1963), WOODS (1965), COOPER and HURD (1968), HALLIG and BREDMORE (1971) among others. The results of these experiments agree with those of the above researches. It is not clear whether the favourable effect on the early yield is due to the stage of development on planting or to the restriction of the root system.

When young tomato plants are planted at the stage when the first cluster is showing colour, the effect of the development stage on the timing of the yield seems to be suitable for the Finnish market.

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SELOSTUS

Taimikasvatusolosuhteiden vaikutus kasvihuonetomaatin satoon

LEA KURKI

Maatalouden tutkimuskeskus

Tomaatin taimikasvatukseen liittyviä tekijöitä, kuten taimiruukkuja, päivänvalon lisänä käytettyä tekovaloa, päivän pituutta, kasvualustan lämpötilaa, sekä tomaatin taimen kehitysastetta tutkittiin Puutarhantutkimuslaitoksessa. Tarkoituksena oli saada Suomen pääasialliselle tomaatinviljelyalueelle (60—65° pohjoista leveyttä) soveltuvia taimikasvatusmenetelmiä.

Kasvuturvetta täyttöaineena käytettäessä soveltuvat turve-, paperi-, muoviruukut ja turvepaakut kylvöruukuiksi silloin, kun niiden koko on 5 × 5 × 5 cm tai lähellä tätä. Siirtoruukuiksi soveltuvat samoista aineista valmistetut ruukut ja paakut noin 10 × 10 × 10 cm suuruisina, kun täyttöaineena on kasvuturve. Muuta täyttöainetta ei kokeiltu. Vähäiset vaihtelut edellä mainituissa mitoissa eivät vaikuta merkitsevästi tomaatin sadon määrään tai aikaisuuteen edellyttäen, että taimet hoidetaan asiallisesti.

Tekovalolähteistä vuoden vaihteen tienoilla käytettynä osoittautuivat korkeapaine-monimetallilamppu HPI 400 W ja korkeapaine-natriumlamppu SON 400 W yhtä tehokkaiksi kuin yhdistelmä, jossa lisävaloa annetaan Floralux 80 W -lampulla ensimmäiset kolme viikkoa taimettumisesta ja sen jälkeen korkeapaine-elohopealampulla HLRG 400 W. Lisävalon määrä taimen tasolla oli kokeissa 2000 luxia Floralux-lamppujen alla ja 3000 luxia korkeapainelamppuja käytettäessä. Vuorokautisen valaistusajan ollessa 16 tuntia oli tomaatin sato vähän aikaisempi ja runsaampi kuin päivän pituuden ollessa 12 tuntia. Tässä yhteydessä ei selvitetty, korvasiko sadon lisäys energian kulutuksen lisäystä.

Kasvualustan suotuisa lämpötila on valon määrän ohella riippuvainen lajikkeesta sekä ilman yö- ja päivälämpötiloista. Lajike 'Revermun' antoi kokeissa aikaisemman ja runsaamman sadon kasvualustan lämpötilan ollessa 15°C, kuin jos se olisi ollut 22°C, kun ilman lämpötila oli yöllä 17°C ja päivällä 22°C. Lajike 'Sonato' suosi lämpimämpää kasvualustaa, eli 22°C edellä mainituissa ilman lämpötiloissa. Ilman lämpötilan aletessa myöhästyi ja väheni kummankin lajikkeen sato. 'Revermun' kehitti kuitenkin lähes yhtä suuren sadon 13/18°C yö/päivä-lämpötiloissa kuin 17/22°C yö/päivä-lämpötiloissa silloin, kun kasvualustan lämpötila oli 18°C. Tomaattisadon ajoittuminen suomalaisia markkinoita ajatellen oli parempi 17°C yö- ja 22°C päivälämpötilassa kuin tätä alemmassa lämpötilassa kasvualustan lämpötilasta riippumatta.

Tomaatin taimen kehitysaste istutettaessa vaikutti suhteellisen voimakkaasti aikaiseen satoon ja kokonaissatoon. Aikaisin ja runsain tomaattisato saatiin, kun taimet istutettiin ensimmäisen kukkatertun ensimmäisen kukan ollessa avautunut. Jos taimet istutettiin ensimmäisen kukkatertun kukkien ollessa vielä täysin nuppuasteella, surkastui ensimmäinen terttu. Jos taimet istutettiin vasta sitten, kun toisen kukkatertun kukat olivat avautumassa, hedelmöityivät sekä ensimmäisen että toisen tertun kukat epätäydellisesti.

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SOME ASPECTS OF THE COWBERRY TRIALS IN FINLAND

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LEHMUSHOVI, A. 1977. Some aspects of the cowberry trials in Finland. Ann. Agric. Fenn. 16: 57—63. (Agric. Res. Centre, Inst. Hortic., SF-21500 Piikkiö, Finland).

The main objectives of a research programme started at the Institute of Horticulture at Piikkiö in 1971 are to adapt cowberry (*Vaccinium vitis-idaea* L.) to field and garden cultivation and to improve and ensure the yield at natural growing sites.

The most important factors determining fruiting in the cowberry are weather at the time of flowering, pollination and illumination.

Fruit yield in the wild can be greatly improved with fertilizers and various mulching materials. However, if satisfactory, economically rewarding results are to be obtained, the cowberry plants must be of a good, vigorously fruiting strain.

The most interesting results have been obtained in the experimental field with substrates and mulches. A peat base has proved the best and on this the cowberry flora has reached 100 % coverage five years from planting. Average yields on a peat base vary between 20—50 kg/100 m^2. Mulching materials on mineral soil also increased both the crop and the size of the berries remarkably.

The berries from field plantings tend to be larger and juicier, whereas the colour and appearance of the wild berries is often more attractive.

Index words: *Vaccinium vitis-idaea* L., cowberry, domestication.

INTRODUCTION

Crops of the cowberry (*Vaccinium vitis-idaea* L.), one of the most important wild berry-bearing plants in Finland, vary greatly from one year to another; amounts reaching the market range from 1 to 20 million kg, and the crop may even fail completely in some parts of the country.

A temperature of —1,5°C can kill 50 % of the cowberry flowers and —3,5°C can spoil an equally large percentage of the buds or the unripe fruit (TEÄR 1972). In the black currant the optimal temperature for pollination is probably +14—16°C; pollination is poor when the average daily temperature is under +10°C and the growth of the pollen tubes is completely inhibited at +6°C (LUCKA and LECH 1974). This may also be so in the cowberry.

Continuous changes occur in the natural habitats of the cowberry, primarily as a result of human activity. Felling, ditching and the application of fertilizer are of obvious importance for the renewal and growth of tree stands but they also have a profound effect on the undergrowth.

It was therefore considered desirable to start investigations on the possibility of cultivating the cowberry in Finland, with a view to ensuring a constant supply of its fruit. By the 1970s, interest in the exploitation of wild fruits had become sufficiently great for practical measures to be taken, and extensive investigations could be undertaken in 1971, when the post of wild fruit researcher was created at the Institute of Horticulture in Piikkiö (southwest Finland).

MATERIAL AND METHODS

The research program begun at the institute comprises a basic ecological study, a study of cultivation techniques in natural habitats and field plantings, a propagation study, a study of the quality of the berries and work on improving the cowberry. The experience and results obtained during the research program are being used in attempts to develop suitable equipment for cultivation and to assess the profitability of commercial cultivation of the cowberry.

Experiments concerning the natural habitats of the cowberry were carried out during the years 1968—1976. A prerequisite for the success of field plantings is on accurate knowledge of the conditions prevailing in the plants natural habitats. Accordingly, soil analyses were performed and temperature, light and moisture were measured in an attempt to elucidate the factors promoting growth and fruiting of the cowberry. The application of fertilizers and various mulching materials on the natural habitats of the cowberry were studied, as were the weather at the time of flowering, pollination and illumination.

The first experimental field planting of the cowberry was made in spring 1968. Attention was paid to the significance to growth and fruiting of the type of substrate, the use of fertilizer, liming and shade (LEHMUSHOVI and HIIRSALMI 1973). The experiment comprised 27 treatments altogether, and four replicas were made of each treatment, so that there was a total of 108 1 m^2 experimental plots.

A mulching trial was set up in the experimental field in 1971. All the plant material for the experiment was obtained from the same population, growing wild in Parainen. The cowberry plants were transplanted in three rows at regular intervals of 30 cm. Each trial plot was two meters long and contained three rows (area 2 m^2); there were four replicas. Planting was established on mineral soil, consisting of coarse sand with some clay in places. Altogether six mulching materials were used: milled peat, bark humus, sand, Leca gravel, chopped straw and sawdust. The total number of treatments was seven. At the beginning of the experiment, in 1971, NPK-fertilizer 6/57/50 kg/ha and N 40 kg/ha was applied to the plots under mulching materials. In spring 1973, P_2O_5 100 kg/ha, K_2O 150 kg/ha and N 40 kg/ha was given, in addition, over mulchings, and in spring 1974, 1975 and 1976 similar amounts of fertilizers were again given.

Fertilizer trials I and II were also started in experimental field in spring 1971. In 1970 plantlets taken from the wild (Parainen) were set at intervals of 10 cm in rows 30 cm apart. Each trial plot was two meters long and contained three rows (area 2 m^2), and there were four replicas. Planting was established on mineral soil, consisting of coarse sand with some clay in places. Fertilizer trial number I received 10 treatments: control (unfertilized), N 100 kg/ha, N 200 kg/ha, K_2O 100 kg/ha, K_2O 200 kg/ha, P_2O_5 100 kg/ha, P_2O_5 200 kg/ha, NPK (2-17-15) 20/170/150 kg/ha, NPK (2-17-15) 40/340/300 kg/ha, NPK (2-17-15) 80/680/600 kg/ha. Fertilizers were given at the beginning of the trial in spring 1971, and then half the quantity was given in spring 1973 and again in spring 1975. Fertilizer trial number II received 9 treatments: control (unfertilized), NPK (11-11-22) 250 kg/ha, NPK (11-11-22) 500 kg/ha, NPK (15-20-15) 250 kg/ha, NPK (15-20-15) 500 kg/ha, NPK (15-20-15) 1000 kg/ha, NPK (2-17-15) 300 kg/ha + N (-20-) 200 kg/ha, NPK (2-17-15) 300 kg/ha + N (-20-) 200 kg/ha + trace elements 200 kg/ha, NPK (2-

17-15) 300 kg/ha + N (-20-) 200 kg/ha + trace elements 400 kg/ha. Trace elements fertilizer includes: K_2O 8,5 %, Cu 12,8 %, Fe 9,8 %, Mn 5,5 %, Zn 5,5 %, S 3,1 %, Mo 1,4 %, B 1,1 % and Na 0,7 %. Fertilization was given at the beginning of the trial in spring 1971, and then half the quantity in spring 1973 and again in spring 1975.

Investigations on the quality of the berries were begun in 1973, in cooperation with the State Institute for Technical Research (Laboratory for Food Research and Technology, Otaniemi). Investigations continued the same place in 1974 and 1976 with material from the wild and from field plantings.

RESULTS AND DISCUSSION

Observations in the wild

The fruit yield in the wild can be greatly improved with fertilizers and various mulching materials. However, if satisfactory, economically rewarding results are to be obtained, the cowberry plants must be of a good, vigorously fruiting strain. Economically, it is not really whorthwile undertaking large-scale improvements of the substrate and making radical changes in the woodland stands, since wild cowberry crops are always fairly small. Two- to three-fold increases in the fruit yield have been achieved with the application of fertilizer. However, if the natural habitat contains abundant grasses and broad-leaved herbs, these benefit from the fertilizer most and drive out the cowberry after two or three growing seasons. Nothing is gained by employing fertilizer in such habitats, unless, of course, the graminoids are first removed with herbicide.

The most important factors determining fruiting in the cowberry are the weather at the time of flowering, pollination and illumination. The setting of good-sized fruit depends not only on suitable conditions for growth, but also on the availability of abundant, good-quality pollen and on cross-pollination, the latter usually increasing both the size and number of the berries.

The weather during flowering is of decisive importance for the success of pollination and fertilization, and for the fruiting percentage as well. Even in years when the fruit yield is good, losses of buds, flowers and unripe berries amount to 30—60 % of the total number of buds formed. In bad years, e.g. with frost in the spring, severe drought or abundant rain during flowering, the proportion rises to 60—100 %. Almost all the flowers may drop off and the fruit yield may be quite negligible.

Pollination by insects has been found to be

Fig. 1. The fertilization experiment in the field.

Table 1. Fruiting percentage in the wild in 1971, 1974—1976.

Treatment	Shoots no.	Flowers no.	Flowers/shoot range	Berries no.	Berries/shoot range	Fruiting %
1971:						
A sunny	10	118	6—18	31	0—11	26
C shady	10	84	6—10	4	0— 2	5
1974:						
A sunny	10	160	6—29	66	0—18	41
B partly shaded	10	170	11—24	64	0—12	38
C shady	8	56	5— 9	20	0— 6	36
1975:						
B partly shaded	91	969	5—31	190	0—15	20
1976:						
B partly shaded	30	338	6—21	115	0— 8	34

absolutely essential for the cowberry. In its natural habitats there often seems to be lack of insect pollinators, and the wide fluctuations in fruiting percentage in field plantings are probably mainly due to insufficient pollination, though the extent to which cross-pollination occurs is also important. Fruiting was not improved when plants were grown in high relative humidity in a plastic greenhouse.

Light also has a considerable influence on the fruiting percentage. Its importance is already apparent during the differentiation of the floral organs and the development of the flowers. The luxuriant, tall-growing cowberry plants often found in shady spruce woods seldom bear abundant flowers or fruit. Most observations indicate that the more open and well illumined the habitat, the higher the cowberry fruiting percentage (Table 1).

Germination percentage in cowberry pollen is usually good, frequently being over 80 %, but in some exceptional cases values below 50 % have been obtained. With the poorer quality pollen, it may be expected that fertilization will be unsatisfactory.

In a sense, the pollination occurring in the cowberry in nature is most often self-pollination, since the stands have developed from single individuals by vegetative reproduction. Pollination between two separate clones occurs much less frequently than within the same clone, although this does of course happen.

Most observations provide clear evidence of the superiority of cross-pollination. Large amounts of pollen ensure satisfactory fertilization, and when fertilization is good, the number of seeds is generally greater and the fruit itself is usually larger. The same effects are achieved with cross-pollination; it gives a much better fruit yield and increases the number of seeds so that the berry size is also greater. Self-pollination is also possible in the cowberry, but it lowers fertility (Table 2).

Substrate, mulching and fertilizer trials in the field

A substrate, fertilizer and liming trial begun in 1968 provides information on the performance of the cowberry in field plantings. Of all the

Table 2. Pollination trials with cowberry in the wild in 1967 and 1968.

Treatment	Flowers no.	Berries		Seeds	
		no.	%	no.	no./berry
1967:					
Free pollination	125	26	21	211	8,1
Self-pollination	139	21	15	39	1,9
1968:					
Free pollination	183	56	31	395	7,1
Self-pollination	76	10	13	29	2,9

factors studied, the substrate was found to exert the greatest influence on the growth of the cowberry shoot. Growth was most vigorous on milled peat; by 1973 the cover had increased from ca. 10 % to 95 % (n = 36). On a mixture of mineral soil and milled peat (1:1) the cover rose to 86 % (n = 36), whereas on pure mineral soil it increased only to 12 % (n = 36). By 1973 the fruit yields achieved were 82 kg/100 m^2 on milled peat, 57 kg/100 m^2 on mixed substrate, and only 14 kg/100 m^2 on pure mineral soil. The increase in shoot growth caused by fertilizer was surprisingly small. Liming appeared to have an unfavourable effect, especially on the fruit yield. Shading stimulated shoot growth to some extent and increased shoot length, but very clearly decreased the fruit yield.

A mulching trial was begun in the experimental field in 1971. Better fruit yields have been obtained in this trial than in any of the other cultivation trials undertaken so far, though, unfortunately, extremely severe spring frost destroyed all the cowberry flowers on open ground in 1975. The first crop was obtained in 1972. On the whole, the yields were small (Table 3), owing to unevenness and gaps in the plants of the various replicas. The plants should not have been set so far apart in 1970 as many of them died in the following growing season. The crop obtained in 1973 was much bigger, and largely confirmed the results of the preceding year. The sand mulch again gave the highest yield, 25 kg/100 m^2, being followed by milled peat, 20 kg/100m^2 and chopped straw, 18 kg/100m^2. The yield from the control was only 4 kg/100 m^2. Fruit size was also bigger with all the mulches than in the control plots (Table 3). The crops obtained in 1974 and 1976 was also good. Leca gravel gave the best yield in 1974, 33 kg/100 m^2 and the sand mulch in 1976, 53 kg/100 m^2. The control plots, with a substrate of bare mineral soil, produce only 8 kg/100 m^2 in 1974, but a good yield in 1976, 17 kg/100 m^2. In considering the yields, it should also be noted that the cover of the cowberry plants was comparatively low in the various trial plots. The highest mean value was obtained in 1974 for the plots with sand mulches 67,5 %, and the cover of, for example, the control plots was only 24,0 %. The plants showed no other notable differences in vigour.

In fertilizer trials, field plantings of the cowberry gave consistently small yields (except in 1976). The reason was that the plants did not thrive as expected on the mineral soil substrate. In places the soil consisted of sand mixed with clay; this is quite unsuitable as a substrate for plants like the cowberry, which require a loose, permeable soil. However, there is no doubt that the fertilizers had a beneficial effect on the fruit yields. Even rather small amounts of fertilizer seem to produce a

Table 3. Cowberry fruit yield and weight of 100 berries during the years 1972—1976 on mulching experiment in the field (Piikkiö).

Treatment	Fruit yield*, kg/100 m^2					Average weight of 100 berries, g				
	1972	1973	1974	1976	1972—1976	1972	1973	1974	1976	1972—1976
Control	0,5	4,4	7,6	17,4	7,48	32,8	29,9	24,3	27,5	28,63
Milled peat	3,0	20,1	9,9	14,4	11,85	35,8	34,2	27,5	28,3	31,50
Bark humus	3,7	13,0	21,6	14,9	13,30	33,3	33,2	26,8	26,5	29,95
Sand	6,0	24,5	30,2	53,0	28,43	33,3	33,8	28,5	32,0	31,90
Leca gravel	3,8	15,8	33,4	12,8	16,45	32,5	32,7	26,5	27,5	29,80
Straw	3,0	17,5	28,5	10,9	14,98	35,0	32,8	27,3	25,0	30,03
Sawdust	3,0	15,8	19,1	12,3	12,55	34,3	33,6	26,3	28,0	30,55

* = severe spring frost destroyed all the cowberry flowers on open ground in 1975

considerable improvements, whereas the cowberry is unable to benefit fully from large applications of fertilizer (Tables 4 and 5).

The quality of the berries

In 1973 and 1974, analyses were made of the quality of the fruit obtained in the various mulching and fertilizer trials. Its taste and aroma substances were found to be fully comparable to those of berries grown in the wild, and in many cases were even superior. The berries from field plantings tend to be larger and juicier, whereas the colour and appearance of the wild berries is often more attractive.

Table 4. The effect of N-, P-, K- and NPK-compost fertilizers on the fruit yield and weight of 100 berries of the cowberry during the years 1974 and 1976.

Treatment	Fruit yield*, kg/100m²			Weight of 100 berries, g	
	1974	1976	range 1976	1974	1976
Control	7,0	27,2	16—49	24,5	30,8
N 100 kg/ha	9,0	31,1	16—56	26,8	31,0
N 200 kg/ha	4,0	29,8	15—45	25,8	29,5
K_2O 100 kg/ha	6,5	35,9	33—39	25,3	29,3
K_2O 200 kg/ha	5,3	28,9	13—45	26,0	30,8
P_2O_5 100 kg/ha	10,3	32,8	22—50	28,8	31,3
P_2O_5 200 kg/ha	8,1	32,2	19—53	26,3	31,5
NPK 20/170/150 kg/ha	3,8	29,3	13—53	25,3	31,8
NPK 40/340/300 kg/ha	4,6	33,8	17—45	24,0	28,5
NPK 80/680/600 kg/ha	3,8	29,5	11—37	24,0	29,8

* = severe spring frost destroyed all the cowberry flowers on open ground in 1975

Table 5. The effect of different kind NPK-compost fertilizers on the fruit yield and weight of 100 berries of the cowberry during the years 1974 and 1976.

Treatment	Fruit yield*, kg/100 m²			Weight of 100 berries, g	
	1974	1976	range 1976	1974	1976
Control	1,4	11,6	7—17	21,3	30,5
NPK (11-11-22) 250 kg/ha	3,2	11,5	8—15	18,0	29,8
NPK (11-11-22) 500 kg/ha	2,3	16,7	9—24	21,3	29,8
NPK (15-20-15) 250 kg/ha	4,6	16,4	7—21	25,3	29,0
NPK (15-20-15) 500 kg/ha	1,6	13,0	3—22	22,8	30,8
NPK (15-20-15) 1000 kg/ha	3,0	18,9	11—27	22,0	30,0
NPK (2-17-15) 300 kg/ha + N (-20-) 200 kg/ha	3,6	15,8	7—22	23,3	27,5
NPK (2-17-15) 300 kg/ha + N (-20-) 200 kg/ha + trace elements 200 kg/ha	2,9	16,8	8—21	23,5	33,8
NPK (2-17-15) 300 kg/ha + N (-20) 200 kg/ha + trace elements 400 kg/ha	2,2	20,1	13—30	20,8	32,0

* = severe spring frost destroyed all the cowberry flowers on open ground in 1975.

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SELOSTUS

Pääpiirteitä puolukan viljelykokeista Suomessa

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Puutarhantutkimuslaitoksessa Piikkiössä aloitettiin puolukan (*Vaccinium vitis-idaea* L.) viljelymahdollisuuksia selvittelevät tutkimukset vuoden 1971 alusta. Tutkimusohjelman päätavoitteena on sovelluttaa puolukka pelto- ja puutarhaviljelyyn sekä sen satojen parantaminen ja varmentaminen jokavuotiseksi luonnonkasvupaikoilla.

Tärkeimmät puolukan marjontaan vaikuttavat tekijät ovat sääsuhteet kukinnan aikana, pölyttyminen ja valaistusolosuhteet. Hyvien kasvuolosuhteiden lisäksi marjakokoon vaikuttavat positiivisesti kunnollinen siitepöly, sen riittävä määrä kukkien pölyttymisessä sekä ristipölytys. Ristipölytys lisää tavallisesti marjojen kokoa ja lukumäärää.

Luonnonsatoja voidaan ratkaisevasti parantaa lannoituksella ja erilaisilla maanpintaan levitetyillä kateaineilla. Kuitenkin pitää puolukkakasvuston olla hyvää ja luonnostaan marjovaa kantaa ennenkuin päästään riittävän hyviin ja taloudellisesti kannattaviin tuloksiin.

Mielenkiintoisimmat tulokset pellolla on saatu erilaisista kasvualusta- ja katekokeista. Lannoituksen vaikutus on osoittautunut varsin mutkikkaaksi, mutta määrätyissä olosuhteissa sen vaikutus satoon on merkittävä. Kasvuturpeella on pellolla yleisesti saavutettu 20—50 kg/100 m^2 satoja. Katteiden satoa ja marjakokoa lisäävä vaikutus on kivennäismaalla ollut erittäin huomattava. Pelkällä karkeaa hietaa sisältävällä kivennäismaa-alustalla puolukka ei ole viihtynyt odotetusti. Kalkituksen vaikutus on osoittautunut useimmiten negatiiviseksi. Varjostus lisää kentällä jonkin verran versojen kasvua ja pituutta, mutta alentaa erittäin selvästi marjasatoa.

Kasvukausina 1973 ja 1974 on tehty laatuanalyysejä pellolla erilaisista kate- ja lannoituskokeista peräisin olevilla puolukoilla. On havaittu, että niiden maku ja aromiaineet kilpailevat täysin metsässä kasvaneiden marjojen kanssa, jopa useassa tapauksessa menevät edelle. Varsinkin marjakoko ja mehukkuus on peltomarjoilla suurempi, metsässä taas väri ja marjojen ulkonäkö saattaa useimmiten olla kauniimpi.

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Seria HORTICULTURA N. 37 – Sarja PUUTARHAVILJELY n:o 37

MULCHING IN THE CULTIVATION OF PICKLING CUCUMBER

RAILI PESSALA and KIRSTI HÅRDH

PESSALA, R. & HÅRDH, K. 1977. Mulching in the cultivation of pickling cucumber. Ann. Agric. Fenn. 16: 64–71. (Agric. Res. Centre, Inst. Hortic., SF-21500 Piikkiö, Finland.)

The suitability of eleven sorts of paper for use as a mulching material in the cultivation of pickling cucumber was clarified. Paper mulches were compared with transparent polyethylene mulch, which had earlier been shown to be of help in safeguarding pickling cucumber cultivation. Under the paper mulches the minimum temperature of the soil was 1–2 degrees higher than that of bare soil. The minimum temperature under paper mulches was about the same as under the clear polyethylene. Light-coloured paper mulches impregnated with paraffin oil proved better than other paper mulches. With these, higher yields were obtained than in cultivations without mulches, but the earliest and biggest yield was achieved with the clear polyethylene mulch. The advantage of paper mulches over polyethylene is that they moulder in the soil after cultivation.

Index words: pickling cucumber, paper mulch, polyethylene mulch.

INTRODUCTION

Large scale cultivation of pickling cucumber can be carried out only in the southern parts of Finland, mainly on the southwestern coast and in the archipelago. Even in these areas crops of this plant, which requires warmth, may fail in the years when weather conditions are unfavourable. Efforts are being made to ensure the success of crops through improved methods. The favourable effect of a clear polyethylene mulch on the growth of the plant and on the early timing and size of the yield has been noted in many experiments (SALOKANGAS 1959, 1967, ANON. 1967, OSARA 1968, ANON. 1970, HÅRDH 1971, PESSALA 1971, HINTZE 1972, SALOKANGAS 1973). The use of polyethylene mulch has thus become common throughout the world as a means of improving growing conditions for plants that require warmth. In Finland, polyethylene mulch has been used in cucumber cultivation.

The difficulty in using polyethylene mulch lies in removing it from the field. It may be removed either during the growing season, when the plants begin to touch the mulch, or afterwards, when the plants have grown through the holes in the mulch.

Experiments with the use of paper mulches in vegetable growing were carried out as early as the first half of this century (SHAW 1926, THOMPSON and PLATENIUS 1932). Soon after polyethylene had been established as a mulching material it was discovered that there was a disadvantage with it, i. e. it does not decay in the soil after cultivation. For this reason it seemed that as a mulching material, in this respect paper was more appropriate than polyethylene.

Experiments were made with different paper mulches in the cultivation of pickling cucumber at the Institute of Horticulture at Piikkiö in 1968—69 and 1971—72.

MATERIAL AND METHODS

The soil in the experimental field was coarse sand. It was moderately poor in nutrients. Yearly fertilizing was carried out as follows (kg/hectare):

	N	P	K
1968	196	72	274
1969	132	102	219
1971	163	102	219
1972	215	102	219

The rows were cultivated 120 cm apart and the seedlings were thinned to a spacing of 20 cm. The size of the experimental plot varied each year, being 24 m^2 in 1968, 6 m^2 in 1969, 18 m^2 in 1971 and 10 m^2 in 1972. There were four replicas, except in 1969, when there were eight. The trial was carried out by a method of randomized blocks. The variety used was 'Superb OE'.

The paper mulches used and their quality can be seen in Table 2. All papers were not used every year. This was inconvenient when interpreting the results. The results with paper mulches were compared with those obtained with transparent polyethylene mulch and with cultivation in bare soil. The polyethylene mulch was 0,03 mm thick. The mulches were 60 cm wide.

The mulches were spread mechanically. The device used in spreading first makes a drill about 10 cm deep, sows at the bottom of the drill and then spreads the mulch over the ground. Mechanical spreading makes demands on the durability of paper. Some papers (mulches nos. 2, 3, 4, 5, 6, 7 and 9) were provided with a thin polyethylene film, which increased the pulling strength of the paper. One paper mulch (no. 10) was strengthened with synthetic fibre for the same purpose.

The mulches were kept on the ground throughout the growing season. In the 1972 experiment there was one treatment in which the transparent polyethylene was removed eleven days after sowing.

Table 1. Monthly average temperatures and monthly rainfall in 1968—69 and in 1971—72 at Piikkiö.

Month	Temperature °C					Precipitation mm				
	Long-term average 1931-1960	1968	1969	1971	1972	Long-term average 1931-1960	1968	1969	1971	1972
May	9,2	7,4	8,7	9,7	9,2	29	37	38	4	20
June	14,0	16,0	16,0	13,8	15,9	43	35	11	14	36
July	17,3	15,4	17,1	16,9	19,5	63	60	48	59	67
August	15,9	16,2	17,2	15,4	16,4	76	44	83	59	100
September	11,0	11,0	10,1	9,3	10,3	64	70	86	29	41

Table 2. Paper mulches used in the experiment.

Mulch	Thickness g/m²	Impregnated with paraffin oil	Perforated 1)	Colour	Used in experiments (year)
1. Clupak paper	70	x	x	light brown	1969, 1971—72
2. Clupak paper + clear polyethylene film	75 + 15	x	x	light brown	1969, 1971—72
3. Clupak paper + clear polyethylene film	80 + 15	x	x	light brown	1968
4. Clupak paper + clear polyethylene film	100 + 20			light brown	1971—72
5. Clupak paper + clear polyethylene film	100 + 20		x	light brown	1971—72
6. Clupak paper + black polyethylene film	90 + 20		x	black	1968
7. Clupak paper + black polyethylene film	100 + 20		x	black	1971—72
8. Clupak paper, bitumenized	100		x	brown	1972
9. Crepe kraft paper + black polyethylene film	75/100 + 20		x	black	1971
10 Crepe kraft paper with synthetic fibre	90			light brown	1968
11. MF-spinning paper	65	x		light brown	1969

1) Some papers were ready-perforated at the appropriate distances.

In 1968—69 and 1971 the effect of mulches on soil temperature was clarified. Each year of the experiment the moisture of the soil was measured using Bouyoucos Moisture Meter with cypsum blocks. During the growing season observations were made on the germination, growth and flowering of the plants. Earliness, quality and quantity were taken into account in the yield. Earliness was determined from the yield during the first 12—14 days of harvesting. The yield was graded according to current quality requirements. Each year harvesting ended when the temperature had fallen below 0°C and the cucumber plants had frozen. Yearly sowing and harvesting dates were as follows:

Year	Sowing	Harvesting
1968	7.VI	12.VIII—18.IX
1969	4.VI	4.VIII—15.IX
1971	14.VI	9.VIII—15.IX
1972	8.VI	28.VII—13.IX

Weather conditions during the growing seasons are shown in Table 1.

RESULTS AND DISCUSSION

Soil temperature

At the beginning of the growing season the soil temperature was a little lower under the paper mulches than in bare soil at 2 p.m.. The difference in temperature increased during the growing season and at the end of it the bare soil was 3—4 degrees warmer in the daytime than the soil under paper mulches. The clear polyethylene raised the soil temperature in the daytime at the beginning of the growing season. Later, when the cucumber plants above the polyethylene mulch and the weeds under it shaded the soil, the soil temperature was lower than that of the bare soil. Under paper mulches the soil temperature was on average lower during the day than under the clear polyethylene (Table 3).

All the mulches raised the minimum soil temperature (Table 3). On average, the minimum temperature under the paper mulches and under the transparent polyethylene was about the same. However, in 1971 Clupak-paper coated with transparent polyethylene (no. 2) and crepe kraft paper coated with black polyethylene (no. 9) differed from other papers, for under these at night the soil was 0,3—0,7 degrees warmer than under the transparent polyethylene. LIPTAY and TIESSEN (1970) and HÅRDH (1971) found that the minimum temperatures were higher under paper mulches than under the clear polyethylene, and they considered this to be due to the fact that paper is more effective to preventing thermal radiation from the soil.

Moisture of the soil

The moisture was measured at a depth of 10 cm under the mulches and in unmulched soil. Differences in moisture under mulches and in bare soil were small. Under both the paper mulches and the clear polyethylene mulch the soil was a little moister than the bare soil, especially at the beginning of the growing season. LIPTAY and TIESSEN(1970) also found

Table 3. Influence of mulches on soil temperature in the years 1968—69 and 1971.

Year/Mulch	Average soil temperature at 2 cm depth, °C					
	June		July		August	
	2 p.m.	min.	2 p.m.	min.	2 p.m.	min.
1968	(28—30.VI)		(1—31. VII)		(1—28. VIII)	
Bare soil	15,8	12,8	21,2	12,4	21,4	13,2
Clear polyethylene	17,0	14,0	19,7	14,9	18,6	15,4
Paper mulch no. 3[1])	15,7	14,3	17,7	14,8	16,5	15,0
" " no. 6	14,8	14,0	17,6	14,4	17,3	14,7
" " no. 10	15,0	13,3	17,8	13,8	17,4	14,6
1969	(10—30. VI)		(1—31. VII)		(1—31. VIII)	
Bare soil	28,8	12,4	25,6	13,0	23,8	12,7
Clear polyethylene	27,3	15,4	24,0	14,9	21,1	14,1
Paper mulch no. 2	27,4	14,1	22,7	13,3	19,9	13,5
1971	(23—30. VI)		(1—31. VII)		(1—21. VIII)	
Bare soil	23,6	12,9	24,1	15,2	22,2	15,7
Clear polyethylene	27,2	14,3	24,7	15,6	20,0	15,6
Paper mulch no. 1	24,0	14,4	22,7	15,4	19,5	15,5
" " no. 2	23,3	14,7	22,0	16,1	19,3	16,0
" " no. 4	20,9	14,2	20,4	15,5	18,7	15,8
" " no. 9	22,9	14,6	22,4	16,1	19,0	16,3

[1]) see Table 2

that polyethylene coated paper held the moisture in the soil in the same way as the transparent polyethylene. According to COURTER and OEBKER (1964) the moisture content under paper mulches is lower than under the polyethylene mulch, but higher than in bare soil.

Germination, growth and flowering

Germination took place soonest and flowering started earliest with the transparent polyethylene mulch. For instance in 1969 the period from sowing to germination was 6 days with the clear polyethylene mulch, 7—8 days with the paper mulches and 8 days in bare soil. The corresponding figures from sowing to flowering were 45 days, 46—47 days and 49 days. In the measurement made at the end of July 1971 it could be noted that growth had been quickest when the clear polyethylene mulch was used (Table 6).

Yield

Variations in weather conditions are reflected in the yield results during the years of the experiment, although no really bad year fell during the experiment. July 1968 was colder than normal (Table 2). The growing season of 1969 was warm, although the average temperature in July was somewhat below the long-term average. Mean temperatures in June, July and August of 1971 were below normal and in 1972 they were above normal.

In 1968 the yield from the soil covered with Clupak paper (no. 3) was somewhat bigger than from unmulched soil. However, the yield was clearly better using the transparent polyethylene mulch than with the above mentioned paper, which was coated with clear polyethylene and impregnated with paraffin oil (Table 4). In 1969 the results from all the mulches were almost the same. The total yield from the mulched plots was 24—29 % higher than from bare soil (Table 5). In 1971 the light brown

Table 4. Effect of mulches on the yield of pickling cucumber in 1968.

Mulch	Total yield		Mean fruit wt.	Marketable yield %	Yield during the first 14 days	
	kg/100 m²	rel.	g		kg/100 m²	rel.
Bare soil	213	100	100	97	53	100
Clear polyethylene	360	169	100	95	172	325
Paper mulch no. 3[1],[2])	247	116	101	97	70	132
" " no. 6	193	91	98	97	46	87
" " no. 10	100	47	95	97	15	28

[1]) see Table 2
[2]) 3 replicas for no. 3

Table 5. Effect of mulches on the yield of pickling cucumber in 1969.

Mulch	Total yield		Mean fruit wt.	Marketable yield %	Yield during the first 13 days	
	kg/100 m²	rel.	g		kg/100 m²	rel.
Bare soil	295	100	119	89	121	100
Clear polyethylene	370	125	107	85	190	157
Paper mulch no. 1[1]	380	129	111	88	166	137
" " no. 2	367	124	108	88	168	139
" " no. 11	372	126	106	87	171	141

F-value 1,71 No significant differences.
[1]) see Table 2

Table 6. Effect of mulches on the yield of pickling cucumber in 1971.

Mulch	Total yield		Mean fruit wt.	Marketable yield	Yield during the first 12 days		Length of vine (20. VII)
	kg/100 m²	rel.	g	%	kg/100 m²	rel.	cm
Bare soil	151	100	65	80	30	100	28
Clear polyethylene	210	139	79	81	64	213	32
Paper mulch no. 1[1])	168	111	73	80	35	117	25
" " no. 2	182	120	70	83	42	140	26
" " no. 4	174	115	67	81	35	117	23
" " no. 5	116	77	58	79	11	37	26
" " no. 7	223	148	75	82	50	167	29
" " no. 9	146	97	69	79	22	73	26

F-value 6,64***
[1]) see Table 2

Table 7. Effect of mulches on the yield of pickling cucumber in 1972.

Mulch	Total yield		Mean fruit wt.	Marketable yield %	Yield during the first 13 days	
	kg/100 m²	rel.	g		kg/100 m²	rel.
Bare soil	166	100	77	94	51	100
Clear polyethylene	363	219	85	94	138	271
" " , 11 days	377	227	94	95	154	302
Paper mulchnno. 1[1])	235	141	77	93	55	108
" " no. 2	263	158	81	93	82	161
" " no. 4	156	94	72	95	39	76
" " no. 5	170	102	80	94	44	86
" " no. 7	130	78	77	93	24	47
" " no. 8	209	126	80	95	63	124

F-value 4,93**
[1]) see Table 2

paper mulches yielded 11—20 % and the transparent polyethylene 39 % increase in crop compared with bare soil. In the same year the soil which was mulched with Clupak paper coated with black polyethylene (no. 7) yielded a bigger total crop than that mulched with the transparent polyethylene, but in the following year this mulch did not have as good an effect on yield (Tables 6 and 7).

In 1972 germination was irregular in many treatments, apparently due to the poor ability to hold moisture of the soil used in the experiment. Under the clear polyethylene mulch cucumber germinated well and the biggest yield was achieved. The polyethylene mulch that protected the plants for the first eleven days yielded a better result than that which was kept on the ground for the whole growing season. Compared with bare soil, the increases in crop using transparent polyethylene mulches were 119 and 127 %. With the Clupak papers (nos. 1 and 2) that were most successful in the experiment yields 41 and 58 % better than those from bare soil were achieved (Table 7).

The use of paper mulches numbers 1, 2, 3, 4, 7, 8 and 11 increased the amount of the total yield and gave an earlier yield than the unmulched cultivation. However, in every year of the experiment the clear polyethylene mulch proved clearly better than other treatments as far as earliness is concerned. No differences could be seen between the quality of the yield in the different treatments (Tables 4—7).

Papers impregnated with paraffin oil were better than other papers. Impregnating paper with oil makes it somewhat transparent and it thus lets through the sun's radiation. The coating of paper with polyethylene did not effect the disintegration of the paper in soil. Transparent polyethylene film on the paper proved more favourable than black polyethylene. The use of black mulches gave rather bad and varying results. COURTER and OEBKER (1964) found in their experiments that black and brown paper increase the early crop and the total crop of cucumber in the same way as black polyethylene. Black polyethylene, however, has been found clearly inferior to transparent polyethylene in the cultivation of pickling cucumber under Finnish conditions (PESSALA 1971). Dark mulches do prevent weeds from growing. However, raising the soil temperature is more important to the plants that require warmth than the preventing weeds.

Considering the technical aspects of cultivation, paper mulches are more profitable than polyethylene ones because they can be left in soil after cultivation.

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SELOSTUS

Katteiden käyttö avomaankurkun viljelyssä

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Puutarhantutkimuslaitoksessa Piikkiössä vuosina 1968—69 ja 1971—1972 suoritetuissa kokeissa selvitettiin yhdentoista paperilaadun soveltuvuutta käytettäväksi katteena avomaankurkun viljelyssä. Paperikatteita verrattiin värittömään muovikatteeseen, jonka aikaisemmissa kokeissa on todettu parantavan avomaankurkun kasvuolosuhteita ja täten varmentavan tämän lämpöävaativan kasvin viljelyä.

Muovikatteen käytössä on vaikeutena muovin poistaminen maalta viljelyn päätyttyä. Paperi puolestaan lahoaa maahan ja olisi täten työteknisesti muovia edullisempi. Katteiden levitys koneella edellyttää kateaineelta hyvää vetolujuutta. Eräät paperikatteet oli vetolujuuden lisäämiseksi päällystetty ohuella muovikalvolla tai vahvistettu synteettisellä kuidulla. Osa papereista oli käsitelty parafiiniöljyllä, joka tekee paperin jonkin verran läpinäkyväksi.

Paperikatteet samoin kuin väritön muovikate kohottivat maan minimilämpötilaa 1—2 astetta sekä pitivät kasvualustan vähän kattamatonta maata kosteampana. Parafiiniöljyllä kyllästetyt, vaaleat paperit olivat katteina muita papereita parempia. Niiden avulla saatiin aikaisempi ja suurempi sato kuin viljelystä ilman katetta. Värittömällä muovikatteella saatiin kuitenkin aikaisin ja runsain sato.

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Seria HORTICULTURA N. 38 — Sarja PUUTARHAVILJELY n:o 38

THE EFFECT OF PLANT MATERIAL AND PLANT DENSITY ON FLOWERING IN THE 'BACCARA' ROSE VARIETY

TAPANI PESSALA

PESSALA, T. 1977. **The effect of plant material and plant density on flowering in the 'Baccara' rose variety.** Ann. Agric. Fenn. 16: 72—79. (Agric. Res. Centre, Inst. Hortic., SF-21500 Piikkiö, Finland.)

The effects of several different rootstocks on flowering in the 'Baccara' rose variety were studied in a research project lasting five years. Productivity of plants growing on their own roots was also compared with that of grafted plants. The greatest yield was obtained with *Rosa indica* 'Major' rootstock. Cuttings yielded 5 % less flowers than the above. The best quality yields were obtained using *R. indica* 'Major' rootstock cultivated in the nursery and winter graft *R. canina* 'Brögs'. 'Baccara' flowered better in autumn than the other samples when plants grafted on *R. indica* 'Major' were used and in spring better than other treatments on a rootstock of winter grafted *R. canina* 'Brögs'.

The yield per square metre of the different 'Baccara' plant material used in the five year experiment was in many cases 5—17 % higher when plant density was 17,5 plants/m^2 compared to the wider spacing of 14 plants/m^2. In most cases the closer spacing slightly reduced the quality of the flowers. Plant mortality was greatest when the plants were grafted on *R. indica* 'Major'. After the experiment, the plants were dug up. The roots and branches of the 'Baccara'/*R. indica* 'Major' sample were heaviest.

Index words: rose, rootstock, cutting, under glass cultivation.

INTRODUCTION

In greenhouse cultivation, roses used for cut flower production are grown on plants grafted onto a rootstock; ungrafted plants, growing on their own roots, are also used sometimes. In Finland, plants grown on rootstocks are used almost exclusively, and winter grafts and also budded plants are becoming increasingly common. According to WIKESJÖ (1972), the following varieties of rootstocks are used for the culture of roses under glass in Europe: *Rosa canina*, seedlings, *R. canina* selections, *R. indica* 'Major', *R. noisettiana* 'Manetti', *R. multiflora* and *R. dumetorum* 'Laxa'. The commonest *R. canina* selections are *R. canina* 'Brögs', *R. canina* 'Inermis', *R. canina* 'Pollmers' and *R. canina* 'Pfender' (WIKESJÖ 1975). All in all, there are perhaps 35 *R. canina* selections that have been experimented with in rose culture (RUPPRECHT 1970).

The use of *R. canina* 'Inermis' rootstock seems to be increasing in Germany and Holland (NOACK et al. 1972). STEFFEN (1969) considers *R. canina* 'Inermis' rootstock to be the best *R. canina* selection. LEEMANS (1964) mentions ten rootstocks which have generally given good results. *R. indica* 'Major' is not one of these. *R. indica* 'Major' rootstock is, however, considered splendid for many rose varieties grown in warm regions, such as Southern Europe (HOLLEY 1969). According to STEFFEN (1969) its culture has also been started in more northerly regions, since culture conditions have improved. It is true that not all the potentialities of this rootstock are yet known. BOSSE et al. (1975) regards its use as puzzling, because grafting does not always succeed and it can thus only be used for certain varieties.

In studies the properties of rootstocks used in greenhouse culture size of yield, quality of the flowers and length of the flowering stem have been clarified, while vigour, longevity and compatibility between rootstocks and plant varieties have been left unstudied (STEFFEN 1972).

MATERIALS AND METHODS

The 'Baccara' plant material was planted in a 10×20 m greenhouse compartment provided with automatic heating, ventilation and a mist system. The benches were 9,42 m long, 1,14 m wide and 0,40 m high. The bottoms of the benches were open so that the roots could penetrate into a 0,5 m layer of gravel beneath the bed. The growing medium was a mixture of sphagnum peat and clayed mineral soil 1:1.

There were 7 different kinds of plant material (Table 1, a—g) and two planting densities were used, 14 and 17,5 plants per net m^2 (9,5 and 12 plants per m^2 of greenhouse area). The plants grafted on rootstocks originated from West Germany, the cuttings from Denmark. There were four replicas and the plot was 1,14 m^2. Each plot contained either 16 or 20 plants, according to the spacing. Owing to difficulties with plant deliveries, the experiment had to be planted in two stages.

During the year they were planted, the plants were bent, pruned and cut in order to make them more vigorous and branch better. Their rest period between December and February was 8—10 weeks. The air temperature during this time was 4—6°C. In the forcing season, night temperature was usually 16—18°C and the highest daytime temperature calibrated on the automatic equipment was 25°C.

Winter pruning was done just before forcing. Irrigation was carried out by pipes with TP-nozzles on both sides of the benches. Nutrients were given mainly in the irrigation water (Table 2).

Flowers of poor quality were included in the total yield. However, flowers that had started to bloom during the rest period were not included. The flowers were graded according to current quality requirements in five groups, I—IV and "others". The last group consisted mainly of flowers that were suitable only for binding. When explaining the results, groups IV and "others" have been combined.

Table 1. 'Baccara' plant materials, their quality and planting dates in the experiments between 1969—1973.

Symbol	Rootstock or cutting	Quality of the material	Planting date
a	*Rosa canina* 'Brögs'	Winter grafting	3. 4. 1969
b	*R. canina* 'Inermis'	Winter grafting	3. 4. 1969
c	*R. (dumetorum) laxa*	Winter grafting	3. 4. 1969
d	ungrafted		17. 3. 1969
e	*R. indica* 'Major'	Nursery grafting	3. 4. 1969
f	*R. canina* 'Brögs'	Nursery grafting	12. 12. 1969
g	R. canina 'Heinsohns Rekord'	Nursery grafting	12. 12. 1969

Table 2. Total radiation outside the greenhouse, annual watering and fertilization of rose plants.

Year	Total radiation mWh/cm²	Watering l/m²	Nutrients N g/m²	P g/m²	K g/m²	No. of fertilizations
1969	105292	–	–	–	–	66
1970	95640	–	–	–	–	64
1971	104228	688	92	19	38	43
1972	94765	859	120	18	38	49
1973	96974	637	84	31	40	35

RESULTS AND DISCUSSION

Quantity of the yield

In 1969—73 the highest yield was given by 'Baccara' grafted on *Rosa indica* 'Major' rootstock (Table 3, materials a—e). Cuttings yielded 5 % less. Grafted on other rootstocks, 'Baccara' yielded 11—18 % less flowers. When combined the relative values of the later yields of the various materials in 1970—73 were as follows: a 100, b 96, c 95, d 105, e 107, f 93 and g 98. Younger plantings of 'Baccara' on nursery grafted *R. canina* 'Brögs' gave the smallest number of blooms.

Noordegraaf (1972) found 'Baccara' produced more flowers on the rootstock *R. indica* 'Major' than on *R. noisettiana* 'Manetti' but Obiol and Cardus (1974) got contrasting results in their experiment. In English trials, *R. indica* 'Major' proved the best rootstock for 'Baccara' (Anon. 1973). Zieslin et al. (1973) stated that productivity in 'Baccara' grafted on *R. indica* 'Major' was greater than that in ungrafted plants because a larger number of flowering branches was produced on grafted plants. Oszkinis (1968) got good results with five varieties on *R. canina* 'Brögs' as did Bulthuis (1976) with two varieties. Further, *R. canina* 'Pollmers' and *R. indica* 'Major' were good rootstocks for the rose variety 'Sonia' (Bulthuis 1976).

Table 3. The influence of plant material and plant density on the total yield of 'Baccara' rose variety.

Material and plant density	No. of flowers per net m² per year 1969	1970	1971	1972	1973	Total yield	Rel. value 1969—73	1971—73
14 plants per net m²								
a[1]) *R. canina* 'Brögs'	136	209	170	195	158	868	100	100
b *R. canina* 'Inermis'	117	186	160	180	150	793	91	95
c *R. laxa*	109	188	145	182	142	766	88	91
d ungrafted	155	228	191	204	154	932	107	107
e *R. indica* 'Major'	180	237	180	207	176	980	113	108
f *R. canina* 'Brögs'	—	180	164	194	172	710	—	103
g *R. canina* 'Rekord'	—	179	156	206	177	718	—	105
17,5 plants per net m²								
a *R. canina* 'Brögs'	140	215	180	215	176	926	100	100
b *R. canina* 'Inermis'	132	214	186	204	170	906	98	98
c *R. laxa*	123	198	176	223	174	896	97	100
d ungrafted	166	244	192	218	159	979	106	100
e *R. indica* 'Major'	210	255	187	216	170	1038	112	100
f *R. canina* 'Brögs'	—	198	161	181	149	689	—	86
g *R. canina* 'Rekord'	—	210	173	211	168	762	—	97

[1]) For symbols, see Table 1

According to KIPLINGER (1969) roses are seldom propagated by stem cuttings. In times when there is a shortage of plants, however, this method has been used on certain varieties. The use of cuttings for cut rose production has yielded good results (WIKESJÖ 1972, ANON. 1973, BULTHUIS 1976). It can also be mentioned that 'Baccara' grafted on *R. canina* 'Inermis' in the later experiment gave a smaller yield than cuttings did during the first growing year (PESSALA 1975). There are also less advantages in growing roses on their own roots in the greenhouse (NOACK et al. 1972, BULTHUIS 1976).

The quantity yield was greatest in 1970. In the following year it was 18 % smaller, in 1972 4 % and in 1973 22 % smaller than the 1970 yield, on average, counted from the total plant material. When different plant materials were compared it could be seen that as the plants grew older, the yield of 'Baccara' grafted on *R. canina* 'Brögs' (nursery graft), *R. canina* 'Heinsohns Record' and *R. laxa* rootstock increased proportionately, while grafted on *R. indica* 'Major' and growing on its own roots the yield decreased.

Quality of the yield

When the proportional quality distribution of flowers is studied, it can be seen that the best quality yield was obtained in 1969–73, with *R. indica* 'Major' and *R. canina* 'Brögs' (winter graft) as the rootstocks. (Fig. 1). The proportional quality distribution was worst on the ungrafted plants, but the total number of I–II class flowers was smaller with *R. canina* 'Inermis' and with younger plantings using *R. canina* 'Brögs' and *R. canina* 'Heinsohns

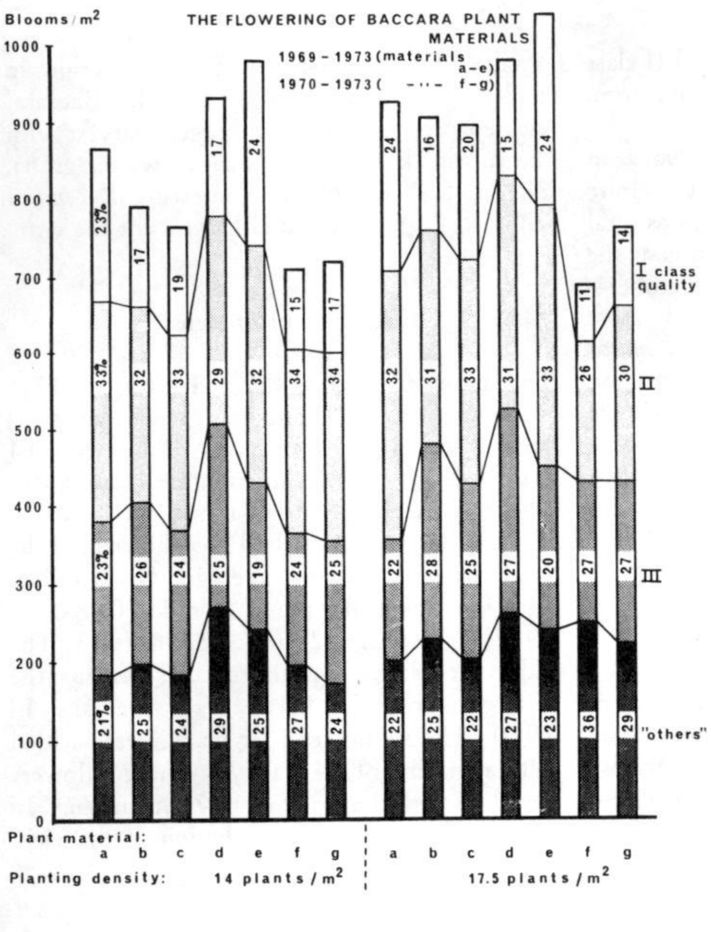

Fig. 1. The effect of plant material and planting density on the quality of the 'Baccara' flower yield in 1969–1973. The figures in the columns give the portions of the quality grades in percentages of the total yield. For plant material symbols, see Table 1.

Table 4. Timing of flowering in various 'Baccara' plant materials. Monthly totals over the five year period.

Material and plant density	Flower yield per m² 1969—1973								Total	Flowers/plant/year
	April¹)	May	June	July	August	Sept.	Oct.	Nov²)		
14 plants/m²										
a³)	99	107	126	163	170	80	89	34	868	12,4
b	81	98	122	156	155	74	84	23	793	11,3
c	75	102	114	144	151	81	75	24	766	10,9
d	87	127	132	172	180	106	95	33	932	13,3
e	94	129	160	181	169	106	100	41	980	14,0
f⁴)	64	106	106	144	135	63	65	27	710	12,7
g⁴)	82	99	95	141	134	78	58	31	718	12,8
17,5 plants/m²										
a	98	120	139	176	171	92	94	36	926	10,6
b	90	116	133	175	176	91	87	38	906	10,3
c	90	119	130	162	173	95	96	31	896	10,2
d	90	130	143	190	184	108	96	38	979	11,2
e	89	147	166	190	178	122	105	41	1038	11,8
f⁴)	59	107	104	144	125	64	61	25	689	9,8
g⁴)	71	124	107	161	131	77	61	30	762	10,9

¹) Some flowers from March are included
²) Some flowers from December are included
³) For symbols, see Table 1
⁴) Yield years 1970—1973

Rekord' as rootstock. Most of the I and II class flowers, troughout the experiment, came from the *R. indica* 'Major' rootstock.

The quality of the flowers did vary in different years, but this may be due to culture techniques and weather conditions, such as total radiation. The poorest quality yield was at the end of the growing season, in October—November. Deformed buds occurred most frequently on 'Baccara' growing on *R. indica* 'Major' rootstock. Plant material and spacing had no clear effect on the number of shoots without flowers early in spring. Blind shoots were cut in March—April, 35 shoots/m² when the spacing was 14 plants/m², and 38 shoots/m²/year when the plants were 17,5/m².

Timing the yield (Table 4)

There were five annual yield peaks, the first in April, the last at the end of October. The harvest season was divided into three periods: April—May, June—August and September—November. 50,5 %, 49,5 % and 49,5 % of the yield of materials a, c, and e, respectively, was obtained in the first and the last period in 1970—73. In the spring period, 'Baccara' yielded proportionally the biggest harvest with the rootstock *R. canina* 'Brögs' (winter graft), 28 %, and in the autumn with *R. indica* 'Major', 24 % of the total harvest for the year.

Effects of plant density

The plots planted with a density of 17,5 plants/net m² (12 plants/m² greenhouse area) yielded a bigger harvest than those with 14 plants/net m² (9,5 plants/m² greenhouse area). The only exception was 'Baccara' on *R. canina* 'Brögs' (nursery graft). In 1969 the yield of the total material was, on average, 10 % higher with the closer spacing, 9 % in 1970, 8 % in 1971, 7 % in 1972, and 3 % in 1973. The older the plants got, the smaller became the difference in yields between the spacings. In 1970—73, 34 flowers per plant were yielded with a spacing of 14 plants/m² and 29 flowers per plant with the spacing of 17,5 plants/m². In 1970—73 the quality distribution of the yield was as follows:

	Grading			
	I	II	III	Others
	Spacing 14 plants/m²			
%	17	34	22	27
Flowers/m²/year	31	61	41	48
	Spacing 17,5 plants/m²			
%	16	32	24	28
Flowers/m²/year	32	62	46	54

The quality distribution was slightly better when the planting density was 14 plants per square metre.

Gross income (Table 5)

The gross income from the yield was counted in 1972 using weekly wholesale prices and grading results. The best gross income was

Table 5. Comparison of the gross income from the yield of the different 'Baccara' plant materials and between planting densities in 1972 (1 $ = 4 Fmk).

Months	Gross income 1972 per net m² in relative values. Plant materials						
	a¹)	b	c	d	e	f	g
14 plants/m²							
April—May .... 108 Fmk/m² =	100	93	94	94	98	89	100
Juni—August .... 57 Fmk/m² =	100	83	86	96	109	95	98
Sept.—November .... 60 Fmk/m² =	100	79	86	96	105	96	113
17,5 plants/m²							
April—May .... 122 Fmk/m² =	100	93	98	91	95	63	85
Juni—August .... 60 Fmk/m² =	100	92	106	101	99	79	95
Sept.—November .... 69 Fmk/m² =	100	83	105	99	108	71	89
14 plants/m²	100	100	100	100	100	100	100
17,5 plants/m²	112	117	127	112	108	84	96

¹) For symbols, see Table 1

Table 6. Final grading of the 'Baccara' plant material 1973.

'Baccara' -variety Rootstock or cutting		Age of plants years	Plant mortality %	Weight of roots g	Weight of stems ¹) g	No. of branches/ plant²)	Thickness of stems mm
a³)	*R. canina* 'Brögs'	5	2	104	183	2,9	9,5
b	*R. canina* 'Intermis'	5	3	96	146	2,4	9,5
c	*R. laxa*	5	1	90	146	2,5	9,0
d	cutting	5	9	94	143	2,3	9,5
e	*R. indica* 'Major'	5	12	137	207	2,9	10,5
f	*R. canina* 'Brögs'	4	8	113	137	3,6	8,5
g	*R. canina* 'Rekord'	4	3	120	151	3,3	8,5
	Plant densities						
	14 plants/m²	4—5	3	107	161	2,9	9,5
	17,5 plants/m²	4—5	8	98	147	2,8	9,0
	Border rows						
	R. canina 'Inermis' (nursery grafts)	5	2	220	297	4,9	9,5

¹) All branches of the plants 0—0,67 m above the ground
²) The branches of the stems (bottom breaks) leaving the ground 0—0,15 m were counted
³) For symbols, see Table 1
1266 plants were measured.

achieved by 'Baccara' on *R. indica* 'Major' rootstock. Gross income from all plants in 1972 was 6 % higher when the spacing 17,5 plants/m^2 was used instead of 14 plants/m^2.

Final evaluation of the plant material (Table 6)

Plant mortality was 5,5 % on average during 1969—73. When the planting density was 17,5/m^2, 7,5 % of the plants died and when it was 14/m^2 only 3 %. Most of the plants lost died during the winter, after the first growing season.

At the end of the experiment the plants were cut down to 0,67 m above the ground. They were then dug up, the roots and stems weighed, thickness of the stems measured and the stem branches (bottom breaks) leaving the ground at 0—0,15 m counted. The weight of the roots and stems of 'Baccara' on *R. indica* 'Major' was greatest. With a density of 17,5 plants/m^2 the weight of the roots and stems was less than with a density of 14 plants/m^2. The plants growing on the border rows at both ends of the benches developed nearly double the weight of those growing in the ordinary plots.

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SELOSTUS

Taimiaineiston ja istutustiheyden vaikutus 'Baccara'-ruusulajikkeen kukintaan

Tapani Pessala

Maatalouden tutkimuskeskus

Puutarhantutkimuslaitoksella vertailtiin vuosina 1969—73 pistokkaiden ja kuuden perusrunkoaineiston vaikutuksia 'Baccara'-ruusulajikkeen kukintaan. Taimien istutustiheydet olivat 14 ja 17,5 kpl/m^2. Suurin sato saatiin, kun 'Baccara oli varrennettu *Rosa indica* 'Major'-perusrungolle. Pistokastaimet antoivat em. aineistoa 5 % pienemmän sadon. Kukkia saatiin vähiten, kun perusrunkoina olivat *R. canina* 'Brögs' (taimistovarte) ja *R. laxa.*

Paraslaatuinen sato oli 'Baccara'-lajikkeella, kun se kasvoi *R. indica* 'Major'-rungolla. Heikkolaatuisimmat kukat saatiin, kun perusrunkona oli taimistovarrennos *R. canina* 'Brögs'. Kukinta ajoittui suhteellisesti enemmän kevätpuolelle, kun perusrunkona oli *R. canina* 'Brögs' (talvivarte) ja enemmän syyskaudelle, kun käytettiin *R. indica* 'Major'-runkoa.

Yhtä poikkeusta lukuun ottamatta kukkivat aineistot 5—17 % runsaammin, kun käytettiin tiheäistutusta normaaliksi katsottavan, 14 kpl/m^2 asemesta. Istutusvuonna 1969 oli satoero suuremman taimitiheyden hyväksi 10 % ja seuraavina vuosina 9, 8, 7 ja 3 %. Sadon suhteellinen laatujakautuma oli hieman heikompi, mutta sato määrällisesti hieman suurempi, kun käytettiin taimitiheyttä 17,5 kpl/m^2 istutustiheyden 14 kpl/m^2 asemesta.

Paras bruttotulo 1972 viikottaisista tukkuhinnoista laskettuna saatiin, kun perusrunkona oli *R. indica* 'Major'. Seuraavaksi parhaat aineistot olivat 'Baccara'/*R. canina* 'Brögs' (talvivarte) ja pistokastaimet.

Taimikuolleisuus oli suurin kun aineistona oli 'Baccara'/*R. indica* 'Major'. Taimikuolleisuus oli 7,5 %, kun istutettiin 17,5 kpl/m^2, ja ainoastaan 3 % taimitiheyden ollessa 14 kpl/m^2. Kokeen päätyttyä taimet nostettiin maasta ja punnittiin. Painavimmat varret ja juuret oli ruusuilla, jos perusrunkona oli *R. indica* 'Major'.

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ASCORBIC ACID CONTENT IN RELATION TO RIPENESS IN FRUITS OF SIX HIPPOPHAË RHAMNOIDES CLONES FROM PYHÄRANTA, SW FINLAND

ARNE ROUSI and HANNELE AULIN

ROUSI, A. & AULIN, H. 1977. **Ascorbic acid content in relation to ripeness in fruits of six Hippophaë rhamnoides clones from Pyhäranta, SW Finland.** Ann. Agric. Fenn. 16: 80—87. (Univ. Turku, Dept. Bot., SF-20500 Turku 50, Finland.)

The L-ascorbic acid content was determined in fruit from six *Hippophaë rhamnoides* ssp. *rhamnoides* individuals growing in Rihtniemi, Pyhäranta (Ab), SW Finland. Each individual represented a different clone. Different stages of ripeness were represented in the fruit samples, which were collected at one week intervals. There was a steady decrease in ascorbic acid content during ripening, the extent differing between individuals. The means of eight parallel analyses per clone at the first stage of full ripeness varied from 165,7 to 293,3 mg %. All six clones differed from each other significantly. Among the clones there was a definite relation between small fruit size and high ascorbic acid content.

Index words: *Hippophaë*, ascorbic acid, ripeness.

INTRODUCTION

The berries of *Hippophaë rhamnoides* belong to the richest sources of vitamin C among edible fruits. Because the fruits are tasty and contain other nutritionally valuable substances, too, it is no wonder that they have been eaten in certain parts of the world for a long time. Many countries have shown interest in the cultivation and breeding of this species, but the most far-reaching work has been done in the Soviet Union, especially with Siberian material. An example of this interest is a symposium-book (KALININA 1970) dealing exclusively with the cultivation and use of *Hippophaë rhamnoides* and containing 32 papers on this theme.

A number of papers have been published containing determinations of the vitamin C content of *Hippophaë rhamnoides* fruits. The results seem to vary within rather wide limits, but certain features are readily recognized. Geographical races of the species, taxonomically recognized as subspecies (ROUSI 1971), differ in ascorbic acid content. DARMER (1952) obtained values of 150 to 310 mg per 100 g (usually denoted as mg%) in ssp. *rhamnoides* and 460 to 1330 mg% in ssp. *fluviatilis*. TROFIMOV (1967) mentioned that the Siberian strains (apparently representing ssp. *mongolica*) have a lower ascorbic acid content than those found in

Western Europe. It seems that ascorbic acid content is a feature that characterizes infraspecific taxa of *Hippophaë rhamnoides.*

The purpose of the present study was to find out how much variation there is in the ascorbic acid content between individuals of a single population of *Hippophaë rhamnoides.* Information on this particular question is very scanty in the literature. Also, little is known about changes in ascorbic acid content during ripening, a factor which must be taken into account when comparing individuals. A morphological comparison of the berries was included in order to determine the relation between individual differences in ascorbic acid content on the one hand and morphology on the other. This information would be helpful in the future in selecting native Finnish material of *Hippophaë rhamnoides* for cultivation and breeding.

MATERIAL AND METHODS

Fruits were collected in 1974 from six individuals of *Hippophaë rhamnoides* ssp. *rhamnoides* growing on rocky shores of the small island Praakkari in Rihtniemi, Pyhäranta (Ab) in southwestern Finland. The bushes were selected from different sides of the island, the distance between two neighbouring individuals varying from 60 to 110 m. On the basis of their location and morphological characteristics it was assumed that they represent different clones.

Fruit samples were collected from each clone at one week intervals, beginning Aug 17 and ending Sept 21. In clone 3, however, no fruits were obtained after Sept 7 because birds had eaten them. The picking was done by cutting the pedicel with scissors. In this way the fruits remained undamaged. They were kept in a styrox box with two cold chargers until they were deep-frozen at the Department of Botany, University of Turku. The time between picking and freezing was ca. 24 hours. Observations on the colour, shape and weight of the fruits, the weight of the seeds and the length of the pedicel were taken from fresh material.

The analyses, 156 in all, were mostly done from fruits that had been kept frozen for one month. A series of analyses consisting of eight parallel assays of each clone was done with fruit samples collected on Sept 1 and kept frozen for two and a half months. For comparison, 54 of the analyses were done from fresh material. No significant differences were found between the ascorbic acid content of the frozen and the fresh material.

A potentiometric titration method developed by Kontio and Casagrande (1945) and Sparrman and Danielson (1969) was used in the determinations of ascorbic acid content. This procedure is based on the classical Tillman's method of titration with 2,6-dichlorphenolindophenol but the point of equivalence is determined by a pH meter instead of visual inspection of the colour of the solution. A Beckman Zeromatic pH meter and a Radiometer platinum electrode were used.

The frozen fruits were squashed in a mortar before thawing, the seeds were removed and the analyses were made from the mashed soft parts of the fruits, including the skins. For an analysis 1000 to 1500 mg of this mash was weighed within an accuracy of 0,1 mg and mixed with 50 ml of 5 per cent metaphosphoric acid (J. T. Baker 0190). The 0,01 normal solution of 2,6-dichlorphenolindophenol used in titrating was tested daily by 0,01 normal Mohr's salt solution.

When the point of equivalence was approached, 0,2 ml of 2,6-dichlorphenolindophenol was added at a time. A magnetic mixer was used, and the pH meter was read one minute after each addition. A CO_2 flow mentioned by Kontio and Casagrande (1945) was not used.

The point of equivalence was determined from a titration curve made from each assay. The ascorbic acid content in mg% was calculated in the following way.

Ascorbic acid content =

$$\frac{V \times 0{,}088 \times 0{,}01 \times 100}{a}$$

where V is the consumption of the reagent in ml and a is the amount of the fruit mash in g (one ml of the reagent is equivalent to 0,088 mg of ascorbic acid).

By this method only the L-ascorbic acid content was taken into account, not the dehydro-L-ascorbic acid, which can also be included into what is usually called vitamin C. Its amount seems to be generally small in ripe fruits, however (cf. MAPSON 1970).

It is known that the so-called reductones interfere with the assay of ascorbic acid in foodstuffs (KUUSI 1960, 1965). The errors caused by this factor may be compensated by the formalin correction. In this way lower ascorbic acid values, so-called corrected ones, are obtained (KUUSI 1965). This correction was not made in the present study where the emphasis was on the comparison of individuals rather than on absolute values.

All ascorbic acid determinations were made in the Laboratory of Jalostaja of the Huhtamäki Company, Turku.

RESULTS

Morphological fruit characteristics of the clones

The colours of the fruits at each picking time are given in Table 1. During ripening the fruits changed colour from yellowish or greyish to more reddish orange tints. When the fruits were considered ripe for the first time, on Sept 1, the colour was similar in all clones except no. 4, which was still slightly raw. In all others the colour gradually again changed towards a more yellowish orange tint, which indicated overripening.

The size and shape of the fruits differed considerably between the clones (Table 2, Fig. 1). The great length and the ovate shape in clone 6, the long cylindrical shape in clone 2 and the almost spherical shape in clones 4 and 5 may be mentioned especially.

Pedicel length is a feature which affects ease in picking *Hippophaë* fruits greatly. The longer the pedicel, the easier it is to pick. Table 1 shows that the mean pedicel length varied from 1,6 to 4,1 mm in different clones.

The fresh weight of 100 fruits (Fig. 2) also varied considerably between the clones. Weight increased in all clones during the ripening

Table 1. The development of colour in the fruits (R. H. S. Colour Chart 1966). Number 151 belongs to the yellow-green, numbers 167—168 to the grey-orange, number 22 to the yellow-orange and numbers 24—30 to the orange group (a larger number meaning a more reddish colour). The letter A next to the number means the strongest, B, C and D progressively weaker intensities.

	17. VIII.	24. VIII.	1. IX.	7. IX.	14. IX.	21. IX.
Clone 1	168 B	28 B	30 C	28 A	28 A	28 A
Clone 2	168 B	28 A	30 C	30 C	30 C	28 A
Clone 3	167 A	25 A	30 C	30 B	—	—
Clone 4	22 A	25 B	28 B	28 B	28 A	28 A
Clone 5	151 A	28 B	30 C	30 A	30 A	28 A
Clone 6	28 B	28 A	30 C	28 A	28 A	28 A

Table 2. The length, breadth and length/breadth ratio of the fruits and the length of the pedicel in mm, measured on Sept 1 with dividers and a ruler. The figures are means and standard errors of 20 measurements each.

	Length	Breadth	Length/breadth	Pedicel length
Clone 1	9,8 ± 0,15	8,3 ± 0,10	1,2	2,2 ± 0,07
Clone 2	9,6 ± 0,17	5,8 ± 0,17	1,7	3,8 ± 0,10
Clone 3	9,5 ± 0,17	7,7 ± 0,16	1,2	3,4 ± 0,11
Clone 4	8,2 ± 0,13	8,4 ± 0,14	1,0	2,1 ± 0,08
Clone 5	8,3 ± 0,11	7,8 ± 0,13	1,1	1,6 ± 0,10
Clone 6	12,1 ± 0,18	8,3 ± 0,13	1,5	4,1 ± 0,11

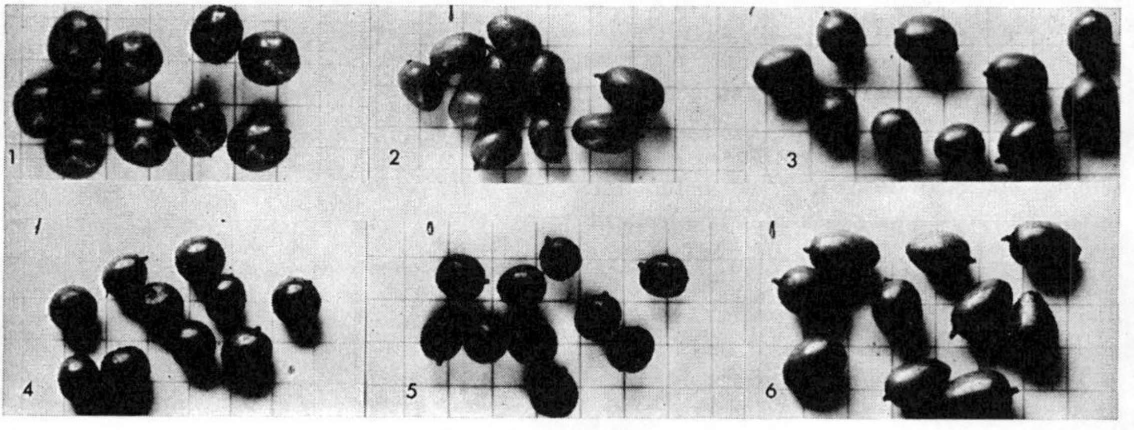

Fig. 1. Fruits of the six individuals studied.

process, and even after the fruit was ripe there was a general tendency for the weight to rise.

The weight of 100 seeds during ripening (Fig. 3) showed an opposite trend. In most clones a decrease in the seed weight was quite evident during ripening, in some of them even when they were becoming overripe.

Ascorbic acid content

The ascorbic acid content of the fruits is shown in Fig. 4. Each value depicted in the graph is a mean of at least two analyses and is based in all cases on material frozen for one month.

In each clone there was a very clear drop of

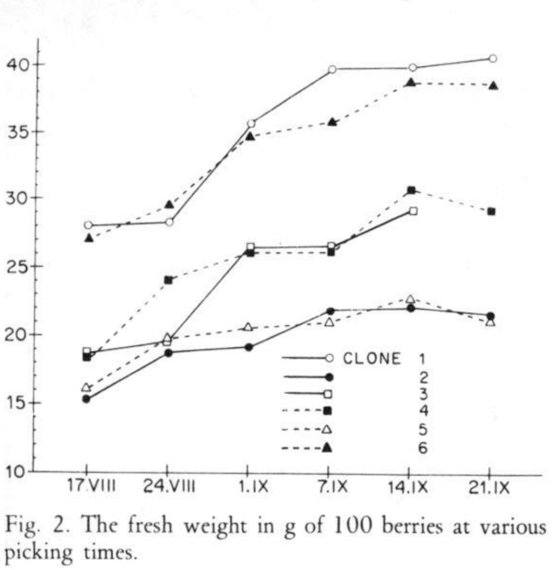

Fig. 2. The fresh weight in g of 100 berries at various picking times.

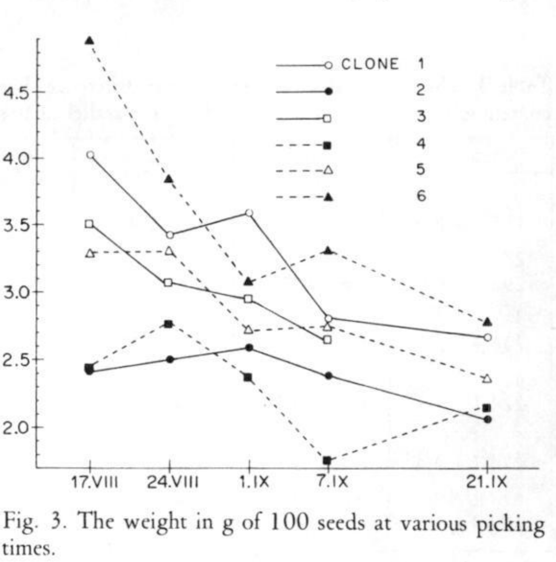

Fig. 3. The weight in g of 100 seeds at various picking times.

the ascorbic acid content during ripening and in the process of becoming overripe. For example in clone 1 the decline was always statistically significant, even between two successive picking times. In some cases there was an apparent increase between two successive picking times, but it was never statistically significant. There were differences between the clones in regard to the steepness of the curve. The drop in the ascorbic acid content was strongest in clone 1 and weakest in clone 6.

The clones differed clearly from each other in the ascorbic acid content. To obtain a statistical comparison between the clones, eight parallel analyses were made from each of the fruit samples collected on Sept 1, when the fruits were for the first time classified organoleptically and on the basis of the fruit and seed colour as ripe. These analyses were made from fruits kept frozen for two and a half months.

Table 3 shows the means of these analyses and the statistical significance of the differences on the basis of the t test. All clones differed significantly from each other, the values of t being highly significant (***) in all but one case where it was fairly significant (*). The highest mean was in clone 2 (293,3 mg%), the lowest in clone 1 (165,7 mg%). It should be noted that the differences between clones 2 and 5 is a reversal of what is shown in Fig. 4, where the means were based on two analyses each and where the rise in clone 5 was not statistically significant.

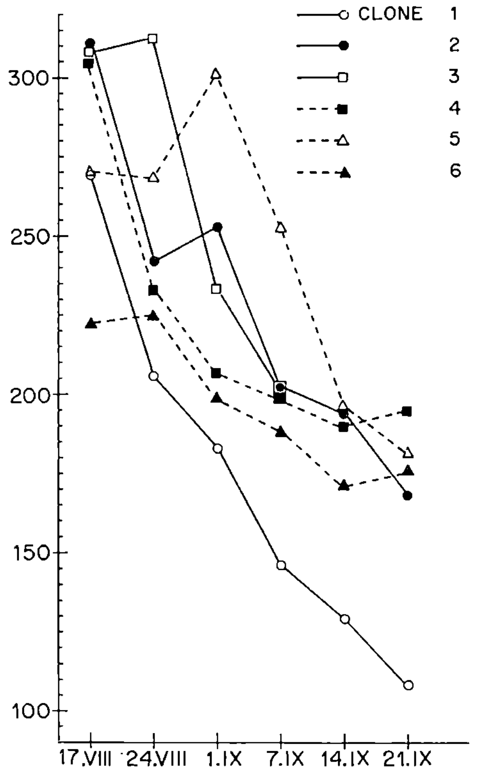

Fig. 4. The ascorbic acid content in mg per 100 g of fruits at various picking times. The graph is based on means of samples kept frozen for one month.

Table 3. The statistical significance of the differences between the clones on the basis of the t test. The ascorbic acid content of each clone is a mean of eight parallel analyses from material collected on Sept 1.

Clone	1	2	3	4	5	6
1 165,7 ± 2,0						
2 293,3 ± 6,0	t = 20,1***					
3 236,4 ± 2,3	t = 23,1***	t = 8,8***				
4 224,7 ± 1,5	t = 23,3***	t = 11,1***	t = 4,3***			
5 274,7 ± 4,4	t = 22,3***	t = 2,5*	t = 7,7***	t = 10,7***		
6 204,0 ± 1,5	t = 14,9***	t = 14,4***	t = 11,8***	t = 9,7***	t = 15,1***	

DISCUSSION

The results show that there are indeed significant differences between individuals of one *Hippophaë* population in regard to the ascorbic acid content. The length/breadth ratio of the fruits or the pedicel length does not show any apparent correlation to the ascorbic acid content. There was, however, a definite relation between fruit size and ascorbic acid content. The comparison of Figs. 2 and 4 shows that the clones with a high fruit weight, particularly 1 and 6, had the lowest ascorbic acid content and those with the smallest fruit weight, namely 2 and 5, had generally the highest ascorbic acid content (definitely so in Table 3).

Darmer (1952) studied *Hippophaë rhamnoides* on the Baltic island Hiddensee near Rügen, East Germany. He also reports on ascorbic acid contents in individual bushes and points out that individuals with small berries had a higher ascorbic acid content than those with larger berries, the values ranging from 150 to 310 mg%, which is almost the same range as in the present material. In the berries from the Alps (ssp. *fluviatilis*) he found values from 460 to 1330 mg%. Darmer considers that the differences are caused by the greater dry weight of the small berries, but according to his data it would not seem possible that this is the sole reason for the great differences, even within the Baltic material. Especially bearing in mind the Alpine material, the differences in the dry matter content of the fruits are far too small to account for the differences in the ascorbic acid content. Darmer mentioned that there was a correlation between redness of the fruit and a higher ascorbic acid content, both in Hiddensee and in the Alps. Fruit shape or pedicel length, on the other hand, varied indepedently of the ascorbic acid content.

According to Fernqvist and Nilsson (1961) small berries generally have a higher ascorbic acid content than large berries because most of the ascorbic acid is in the outer parts of the fruits and there is more surface in 100 g of small berries than large ones. This factor may at least partly account for the relation of fruit size to ascorbic acid content in *Hippophaë*, although nothing is known about the location of the ascorbic acid in the fruits of this plant.

Among the black currant varieties analyzed by Kuusi (1965) there seems to be a similar relation between ascorbic acid content and berry size. When the 100 berry weights given by Säkö (1973) are compared with the results of Kuusi, based on material from the same variety trials, this becomes quite apparent.

In Russian literature there are many examples of differences in the ascorbic acid content of *Hippophaë rhamnoides* individuals of the same geographic origin (see e.g. Trofimov 1967, Kalinina 1970). The data are mostly from cultivated clones selected because of their good fruit yield. The correlation between small fruit size and high ascorbic acid content does not hold good in all cases. For example, the data given by Zhil'tsova (1970) show quite a reverse trend. An interesting case is reported by Trofimov (1970). In his material in the Botanical Garden of the Moscow University he had a rather small-fruited individual from the Botanical Garden of Kaliningrad (the origin is not specified) which produced fruit with an exceptionally high ascorbic acid content (500—600 mg%). This individual died in the winter of 1967—68, but a seedling from it bore fruit with almost as high an ascorbic acid content (in 1969 450,6 mg%). The genetic basis of this characteristic is thus quite obvious. It may be mentioned that Fejer et al. (1973) proved by crossing experiments the existence of a genetic control of the ascorbic acid content among raspberry varieties.

In our material the drop in the ascorbic acid content during ripening and after ripening was quite obvious. There were differences between clones in the amount of the decrease (e.g. clones 1 and 6 in Fig. 4). Probably these differences have a genetic basis. According to Darmer (1952) there was a rise in the ascorbic acid content during ripening (during increase of the orange colour) and a drop after ripening, but in some strains the content was more or less stable during the ripening process. Many Russian investigations show, however, a definite decrease during ripening (see TROFIMOV 1967) which is in accordance with our results. TROFIMOV also stresses the effect of various environmental factors on the ascorbic acid content.

In black currant, also, the ascorbic acid content generally shows a decrease during the ripening of the berries (HÅRDH 1964). According to the results of BOGDANSKI et al. (1956) and NILSSON (1969) certain varieties of black currant are characterized by an increase rather than decrease during ripening. This would again stress an intraspecific variation in the stability of the ascorbic acid during ripening.

Ascorbic acid is easily lost by oxidation. In fruits this may be prevented and the stability of the ascorbic acid thus enhanced by certain chemical factors like a low pH, polyhydroxy acids, or anthocyanin, flavanone of flavonole pigments, e. g. quercetin (see MAPSON 1970). It is interesting to note that quercetin glycocides have been found among other flavonoids from fruits of *Hippophaë rhamnoides* (HÖRHAMMER et al. 1966). Together with the acids they may be significant in stabilizing the high ascorbic acid content in the fruits of this species.

It can be concluded that the ascorbic acid content of the fruits of *Hippophaë rhamnoides* is affected by many factors. Determination at one stage of ripeness is certainly not enough. When material is selected for cultivation or for breeding purposes, enough individuals should be tested from each population in order to find the best genotypes.

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SELOSTUS

Askorbiinihappopitoisuus ja sen riippuvuus kypsyysasteesta kuudella samaan populaatioon kuuluvalla tyrnikloonilla

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Tutkimuksen kohteena oli kuusi *Hippophaë rhamnoides* L. ssp. *rhamnoides* -yksilöä, jotka kuuluivat samaan populaatioon Pyhärannan (Ab) Rihtniemessä. Kukin näistä yksilöistä edusti eri kloonia. Viikon välein kerätyistä, eri kypsyysasteita edustavista marjanäytteistä analysoitiin C-vitamiinin tärkeimmän komponentin, L-askorbiinihapon määrä. Sekä kypsymis- että ylikypsymisvaiheessa havaittiin selvä askorbiinihappopitoisuuden lasku, jonka jyrkkyys kuitenkin vaihteli eri yksilöissä.

Ensimmäisessä kypsässä vaiheessa (1.IX.) kerätyistä marjanäytteistä tehtiin kahdeksan rinnakkaista analyysiä kloonia kohti eri kloonien askorbiinihappopitoisuuden tilastolliseksi vertailemiseksi. Kaikki kuusi kloonia erosivat silloin toisistaan merkitsevästi. Pienin näistä analyyseistä kloonia kohti laskettu keskiarvo oli 165,7 mg ja suurin 293,3 mg 100 grammassa marjoja. Pienimarjaisimmilla klooneilla oli korkein, suurimarjaisimmilla alhaisin askorbiinihappopitoisuus. Muilla marjojen morfologisilla ominaisuuksilla ei ollut selvää yhteyttä askorbiinihappopitoisuuksiin. Voimakas populaationsisäinen vaihtelu askorbiinihappopitoisuudessa on otettava huomioon valittaessa tyrniaineistoa viljelyä tai jalostusta varten.

ANNALES AGRICULTURAE FENNIAE, VOL. 16:88–96 (1977)
Seria HORTICULTURA N. 40 — Sarja PUUTARHAVILJELY n:o 40

YP, A NEW CLONAL ROOTSTOCK FOR APPLE

JAAKKO SÄKÖ

SÄKÖ, J. 1977. **YP, a new clonal rootstock for apple.** Ann. Agric. Fenn. 16:88–96. (Agric. Res. Centre, Inst. Hortic., SF-21500 Piikkiö, Finland.)

The Institute of Horticulture is introducing to Finnish fruit farmers a new clonal apple rootstock raised at Piikkiö and named YP. It originates from the seed of an open pollinated Siberian crab apple tree, *Malus baccata* (L.) Borkh. Frost hardiness has been found to be better in YP than in any other rootstocks tested in Finland. YP can be reckoned as a vigorous rootstock. Its growth vigour is close to that of the Swedish A 2. With late bearing scion varieties, such as 'Åkerö' and 'Alice', YP has proved more precocious than A 2. Trees grafted on YP have cropped as well as those on A 2, in some varieties even better. Compared to 'Alice' variety grown on MM stocks, only trees grown on MM 104 have produced slightly higher yields than YP.

YP can be propagated fairly easily in stool-beds. It will result 5—8 rooted shoots per a mother stock. It is also raised easily from soft cuttings and root pieces.

Morphologically, YP rootstock, as a tree and as an apple, is closer to a cultivated apple than to the Siberian crab apple. It has proved compatible with all the scion varieties tested in Finland.

Index words: YP rootstock.

INTRODUCTION

Finnish fruit farming, which consists almost entirely of apple production, is greatly restricted by the severe climate. Cold winters, occurring at rather frequent intervals, often cause heavy losses to growers. Besides injuring and killing trees, the cold winters cause great variation in annual apple production.

At least five unusually cold winters have occured during the last 40 years, and have been disastrous for apple orchards in Finland. The winter of 1939—40 was the coldest, and the injury caused then was clinched during two following winters. Fruit farming in Finland almost collapsed. But the winters of 1946—47, 1955—56, 1962—63 and 1965—66 were also unusually cold, causing extensive damage to apple orchards (SÄKÖ 1957 b, SÄKÖ and PESSALA 1967). Some minor frost injuries may even occur during winters when the temperature remains normal. For this reason Finnish apple production today is mainly located in the southwest coastal area, where the winters are milder than they are inland.

In most cases frost injuries occur because the trees do not stop growing early enough in the autumn and go into dormancy before the low temperature period starts. It is characteristic of the maritime climate of Southwest Finland that the growth periods are rather cool and the autumns wet. This causes growth to continue late and delays the onset of dormancy. Cold injury appears mostly in the form of injured leaf buds and dead shoots. If the frost period continues for a long time, injuries are also found at the branch angles, where transport and assimilation products take a long time to move, and which are therefore susceptible to frost. Very often the branch angles are injured just at the snow level, where the temperature is lowest.

The use of plant material which is hardy and well-adapted to the climatic conditions is a premise for avoiding winter injuries. Rootstock plays a major role in determining frost hardiness in apple trees. It has both a direct and an indirect effect on the tree. The direct effect is manifest in hardiness of the rootstock itself when the soil is deep frozen. The indirect effect shows in the reaction of the grafted scion variety: how early defoliation takes place and how early the shoots are ripe for dormancy (Table 1). There is clear evidence that trees on certain rootstocks will go into dormancy earlier than those on some other stock. The commonly used Malling rootstock types M 1, M 2, M 4, M 7 and M 9 have not proved sufficiently hardy for Finland (Meurman 1943, 1947, Säkö 1958). Trees grafted on Malling types 4 and 9 have proved the most susceptible to frost injuries. Some seedling rootstocks of hardy varieties such as 'Antonovka' and 'Sugar Miron' have proved hardier under winter conditions than the Malling types (Säkö 1975). Furthermore, trees grown on seedling rootstocks have not shown more individual variation in growth and cropping than trees on clonal rootstocks (Säkö 1953, 1957 a). However, today seedling rootstocks are not much used for apples. The commonest and almost exclusively used apple rootstock in Finland now is the Swedish clonal rootstock, A 2. The Institute of Horticulture at Piikkiö is at present introducing and releasing a clonal apple rootstock named YP (abbreviation of the words Yltöinen, Piikkiö). This paper compares results with YP with those of other rootstocks.

Table 1. Defoliation and ripening of shoots in apple varieties grown on different rootstocks in autumn 1970. 0 = unripe, 100 = fully ripe.

Variety	Rootstock	Ripening of shoots Oct. 10 0–100	Variety	Rootstock	Ripening of shoots Oct. 10 0–100
'Quinte'	YP	100	'Lobo'	YP	84
"	A 2	100	"	A 2	78
			"	M 7	78
'Ranger'	YP	99			
"	A 2	97	'Alice'	YP	84
"	M 7	97	"	MM 109	80
			"	'Anton.'seedl.	78
'Mantet'	YP	99	"	A 2	76
"	A 2	95	"	MM 111	75
"	M 7	96	"	M 7	72
			"	MM 102	70
'Raike'	YP	98	"	MM 104	70
"	A 2	93	"	MM 106	67
			"	MM 101	63

MATERIAL AND METHODS

In 1955–56 seeds from an open pollinated Siberian crab apple, *Malus baccata* (L.) Borkh., were sown. The seedlings obtained were stooled and the root formation of the shoots studied. Ten well rooted clones were selected from this material. One of these had a better root formation than the others. It was given the mark Mb 4 (*Malus baccata* 4). Ever since, this rootstock, today named YP, has been tested with several scion varieties and compared with other rootstocks, especially with the Swedish A 2 and English M (Malling) and MM (Malling Merton). This study has included determination of the influence of rootstock on time of defoliation and hardiness, as well as on growth, precocity and cropping of the tree. The hardiness of the rootstock itself has been tested in an experimental field which is kept clear of snow throughout the winter to allow the soil to freeze deep. In laboratory tests what is known as the exosmosis method has been used, in which the frost-treated plant material is kept in distilled water and the electric conductivity of the electrolytes thus obtained is measured. The more the plant's cells are injured, the better conductivity will be (Wilner 1955, 1959). Propagation of YP and A 2 rootstocks has been compared in stool-beds earthed with sandy soil, peat and sawdust. Furthermore, propagation by cuttings and root pieces has been studied.

RESULTS

Trees of most apple varieties grafted on YP have defoliated earlier than those on other rootstocks. This was especially evident in autumn 1970 (Table 1).

In 1964–66, when the winter 1965–66 was exceptionally cold, the frost hardiness of several apple rootstocks was tested in the field kept clear of snow. In this experiment YP was the only rootstock which stood up to the treatment without frost injuries. 'Antonovka' seedling rootstock suffered some slight injuries, but all the other rootstocks, A 2, M 2, M 7, M 25 and the MM clones of 101, 102, 103, 104, 105, 106, 109, 111 and 112 were killed by frost. In the exosmosis method YP also proved the hardiest compared to other material (Table 2).

On the basis of the results obtained in field and laboratory tests the hardiness of rootstocks under Finnish conditions are assessed as follows:

YP	very hardy
'Antonovka' seedling	hardy
A 2	moderately hardy
M 7 M 111 M 2	not acceptable hardy
'Bittenfelder' seedling 'Grahams Jubiläum' seedling 'Normandie' seedling M 4 M 1 MM 103 MM 110 MM 109 MM 106 M 9 M 25	susceptible to frost injuries
MM 104 MM 101 MM 112 MM 105 MM 113 MM 102	very susceptible to frost injuries

Table 2. Results of frost treatment under laboratory conditions, February 1964. Treated shoots tested with exosmosis method. The smallest electric conductivity shows least frost injuries. Conductivity figures are means of five treatments.

Rootstock	El. conduc.	Rootstock	El.conduc.
YP	491	MM 106	1046
'Antonovka' seedl.	577	M 1	1084
A 2	791	M 25	1092
M 7	833	MM 104	1124
MM 111	834	MM 101	1190
M 2	857	MM 112	1246
MM 103	903	MM 105	1308
MM 110	966	MM 113	1313
MM 109	1032	MM 102	1530

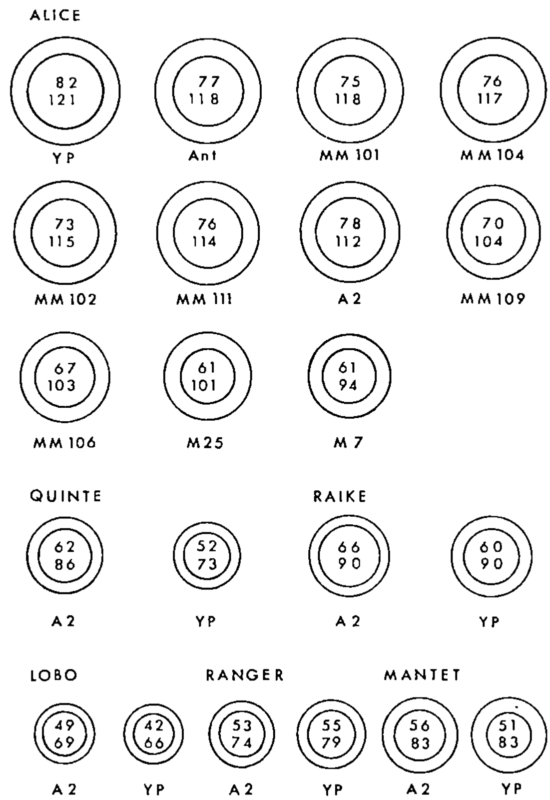

Fig. 1. The trunk diameters (in mm) of the trees grafted on different rootstocks after 5 and 8 years of planting.

Growth of the varieties grafted on different rootstocks is given in trunk diameters, measured five and eight years after planting (Fig. 1). The measurements were made 30 cm above soil level. The trees were planted so deep that the graft unions were level with the soil surface. The rootstock effect varied in different varieties. Thus the variety 'Alice' grew more vigorously on YP than A 2. In most of the other varieties, however, growth vigour was less on YP than A 2. Least growth was measured in trees grafted on M 7, M 25 and MM 106.

Trees of the very late bearing variety, 'Åkerö', proved more precocious when grown on YP than on A 2 rootstock. 'Alice', which is also a late bearing variety, cropped more heavily on MM 104 and on YP than on other rootstocks (Table 4). The varieties 'Quinte', Ranger', 'Mantet, 'Raike' and' 'Lobo' bore about the same crops when grown on YP as on

Table 3. Yields in an apple rootstock trial. Trees planted in 1964. Planting distance 4×4 m.

Variety	Rootstock	Yield kg per tree and year		Yield t per ha and year		Apple size Extra >60 mm %
		1971–76	1976	1971–76	1976	1971–76
'Atlas'	YP	42,8	93,2	26,7	58,3	70
"	A 2	17,2	19,7	10,7	12,3	58
'Lobo'	YP	7,9	19,7	4,9	12,3	56
"	A 2	8,5	26,0	5,3	16,3	53
'Åkerö'	YP	5,5	11,8	3,4	7,4	44
"	A 2	0,8	1,7	0,5	1,1	8

Note! No yield in 1975 because of severe spring frosts.

A 2 rootstocks (Table 5). Trees grafted on M 7 produced much smaller yields than trees on other stocks. It seems that low grafting and planting so that the union is at soil level is more profitable than grafting 30 cm higher (Table 6). On the other hand, planting on a low ridge (about 30 cm) has given a higher yield than planting on flat soil. This is due to the fact that the temperature on the ridge is higher than on flat soil. In this experiment trees grafted on YP have cropped more heavily than those on A 2 (Table 7).

The size and quality of apples have been good in varieties grown on YP. Some varieties, such as 'Ranger', 'Raike', 'Alice', 'Atlas' and 'Åkerö', have produced more extra-large apples when grafted on YP than on A 2 (Tables 3—7).

When rootstocks are propagated in stool-beds, root formation in the shoots is stimulated by earthing with sawdust instead of soil (Säkö 1959). In a stool-bed trial in 1975—76 sawdust also proved better than peat for root formation. More shoots developed with sawdust earthing than with peat and sandy soil (Table 8). In this trial the number of shoots produced by A 2 was smaller than that of YP, but root formation was better on A 2 than on YP rootstock.

Table 4. Yields in an apple rootstock trial. Trees planted in 1967. Planting distance 2×4 m. Variety 'Alice'.

Rootstock	Yield kg per tree and year		Yield t per ha and year		Apple size Extra >60 mm %
	1971–76	1976	1971–76	1976	1973–76
YP	7,9	26,4	9,8	33,0	20
A 2	4,3	14,0	5,4	17,5	13
'Anton.'seedl.	5,3	16,9	6,6	21,1	26
M 7	1,1	4,2	1,4	5,3	13
M 25	6,3	24,9	7,9	31,1	19
MM 101	2,7	9,4	3,4	11,8	11
MM 102	6,6	17,8	8,3	22,3	6
MM 104	8,6	28,5	10,7	35,6	16
MM 106	5,2	18,1	6,5	22,6	15
MM 109	5,9	18,5	7,4	23,1	13
MM 111	7,2	24,1	9,0	30,1	9

Table 5. Yields in an apple rootstock trial. Trees planted in 1967. Planting distance 2×4 m.

Variety	Root-stock	Yield kg per tree and year		Yield t per ha and year		Apple size Extra >60 mm %
		1971–76	1976	1971–76	1976	1971–76
'Quinte'	YP	9,5	25,6	11,9	32,0	40
"	A 2	10,2	27,1	12,8	33,9	39
'Ranger'	YP	13,9	33,0	17,3	41,0	29
"	A 2	11,1	26,3	13,9	32,9	18
"	M 7	4,7	10,8	5,9	13,5	27
'Mantet'	YP	8,6	20,0	10,7	25,0	12
"	A 2	8,8	17,0	11,1	21,0	11
"	M 7	4,4	12,9	5,6	16,1	24
'Raike'	YP	15,7	36,3	19,7	45,4	58
"	A 2	14,6	34,3	18,2	42,9	54
'Lobo'	YP	2,3	7,9	2,9	9,9	85
"	A 2	2,6	7,8	3,2	9,8	72
"	M 7	0,8	3,5	1,0	4,4	81

Note! No yield in 1975 because of severe spring frosts.

Table 6. Yields in an apple rootstock trial. Grafting at different heights. Trees planted in 1968. Planting distance 4×4 m.

Variety	Root-stock	Yield kg per tree and year		Yield t per ha and year		Apple size Extra >60 mm %
		1971–76	1976	1971–76	1976	1971–76
High grafting. Union 30 cm from soil surface.						
'Lobo'	YP	3,3	12,3	2,1	7,7	95
"	A 2	2,6	8,9	1,6	5,6	73
'Åkerö'	YP	2,9	10,0	1,8	6,3	31
"	A 2	2,1	7,5	1,3	4,7	19
Low grafting. Union at soil surface.						
'Lobo'	YP	5,0	18,2	3,1	11,4	87
"	A 2	4,5	18,4	2,8	11,5	89

Note! No yield in 1975 because of severe spring frosts.

Table 7. Yields of Lobo apple trees in flat soil and ridge planting grafted on A 2 and YP rootstocks. Trees planted in 1965. Planting distance 2×4 m.

Variety	Rootstock	Yield kg per tree and year		Yield t per ha and year		Apple size Extra >60 mm %
		1971–76	1976	1971–76	1976	1976
'Lobo'	A 2					
Flat soil		2,7	8,5	3,4	10,6	27
Ridge planting		3,6	10,0	4,4	12,5	22
'Lobo'	YP					
Flat soil		7,4	22,9	9,3	28,7	25
Ridge planting		9,9	25,5	12,4	31,8	25

Note! Height of the ridge about 30 cm.

Table 8. Shoot and root formation of A 2 and YP rootstocks in stool-beds per 100 mother stocks. Earthing: sandy soil, peat and sawdust.

Rootstock	Number of shoots	Diameter of rootstock >6 mm <6 mm Root formation				Well-rooted shoots together	
		good %	weak %	good %	weak %	number of shoots	%
A 2							
Sandy soil	533	24	11	36	29	320	60
Peat	589	37	9	40	14	454	77
Sawdust	794	36	17	26	21	494	62
YP							
Sandy soil	680	11	20	18	51	193	29
Peat	716	21	15	20	44	290	41
Sawdust	793	23	14	23	40	364	46

DISCUSSION

The frost hardiness of an apple tree is a complicated process depending on many factors. Besides the plant material, site conditions and the growing technique play their part. However, the hardiness of the scion variety itself is most important. That is why under Finnish climatic conditions, where apple production is practised at its most northerly limits, it is difficult to find apple varieties which are hardy enough and which also fulfil the quality requirements. Long experience has shown that a hardy rootstock is still an important factor to lower the risk of cold injuries in apple trees. YP has proved the hardiest of all rootstocks tested under Finnish conditions.

Early defoliation is a characteristic of the Siberian crab apple as is the early break of dormancy in spring. YP also starts dormancy a little earlier than A 2, M and MM rootstocks. Moreover YP has the effect of hastening dormancy in the scion varieties grafted on it. On the other hand YP bursts into leaf a little earlier in spring. This phenomenon does not cause any risk, however, because in Finland the spring begins rather late. There is no danger of a severe second winter. No observations have yet been made to determine whether dormancy breaks earlier in scion varieties grown on YP than on other stocks.

Growth vigour of YP is considered to be about the same as that of A 2 and the usual seedling rootstocks; it will be classified into vigorously growing group. However, in the Finnish climate, where the growing season is quite short — Southwest Finland has about 170 days when the mean temperature is at least + 5°C — trees on vigorous rootstock will not grow so vigorously as in more southern latitudes.

With some late bearing varieties such as 'Alice' and 'Åkerö', trees grafted on YP have been more precocious than those grafted on A 2. This phenomenon was also obvious when two and three-year-old maiden trees of these varieties were treated with B-nine growth substance. The trees treated which had been grafted on YP were more retarded in growth and yielded earlier than those growing on A 2. On the whole, cropping has been much the same on trees grafted on YP as those on A 2. In the trial in which 'Alice' variety was tested with

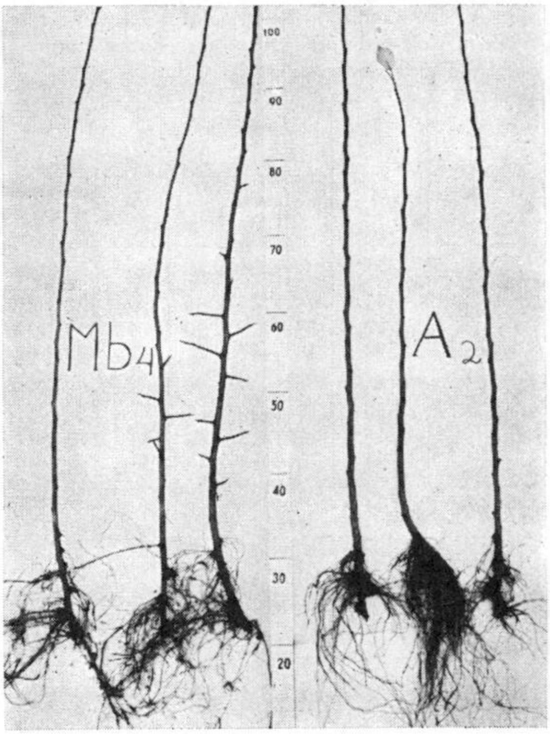

Fig. 2. YP (Mb 4) and A 2 rootstocks propagated in stool bed.

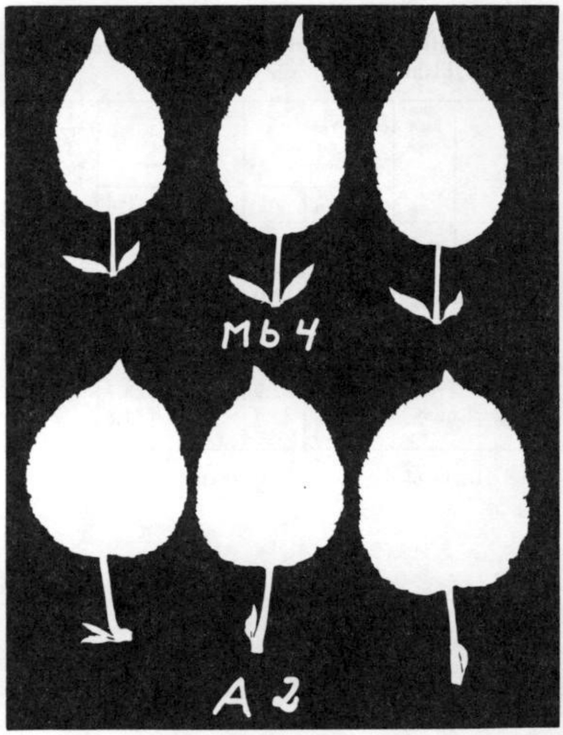

Fig. 3. Leaves of YP (Mb 4) and A 2 rootstocks.

eleven different rootstocks including six MM stocks, the mean yields were highest on trees growing on MM 104 and YP (Table 4). The apple size of trees on YP has been rather good.

Siberian crab apple seedlings used as rootstocks have often shown incompatibility with commonly cultivated apple varieties (Czynczyk and Pieniazek 1967). The union between the rootstock and the scion sooner or later may break. Although the YP clone originates from an open pollinated Siberian crab flower, it is morphologically quite far from it. The mother tree from which the seed was taken, has grown close to an apple variety collection with hundreds of varieties. Therefore, it is not possible to identify the pollinator. An adult YP tree differs from a Siberian crap apple in that it is thornless and its apples are much bigger, about 2/3 the size of a normal cultivated apple. So far, no case of incompatibility has occured with varieties grafted on YP.

The propagation of YP is fairly simple in stool-beds. About 5 — 8 rooted shoots are obtained from one mother stock. Rooting is satisfactory in the stooled shoots, about as good as with M and MM stocks, but poorer than A 2. This last mentioned rootstock is exceptionally easy to propagate in stoolbeds and by cuttings. In the recent tests a rooting rate of about 60—80 % was obtained from A 2 soft cuttings compared to about 40—60 % with YP. Propagation by root pieces has yielded 80—90 % of the rooted shoots with both A 2 and YP. YP shoots are somewhat thorny, but not to the extent that this could harm grafting and budding (Fig. 2).

On the basis of the results given it is obvious that the clonal apple rootstock YP is a very promising variety for use under Finnish climatic conditions and elsewhere where frost hardiness is an important and serious question in apple growing. Moreover, YP has a favourable effect on cropping of the trees.

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SELOSTUS

YP, uusi suvuttomasti lisättävä omenapuuperusrunko

JAAKKO SÄKÖ

Maatalouden tutkimuskeskus

Puutarhantutkimuslaitos esittelee viljelyyn uuden suvuttomasti lisättävän omenapuuperusrungon merkinnällä YP. Se on peräisin marjaomenapuun, *Malus baccata* (L.) Borkh., vapaasta pölytyksestä.

Vuosina 1955—56 kylvettiin laitoksessa marjaomenapuun siemeniä tarkoituksena selvittää siementaimien juurtumista suvuttomassa lisäyksessä. Emorunkojen kasvettua kaksi vuotta, niiden rungot katkottiin noin 15 cm pituisiksi tyngiksi, joiden annettiin vesoa. Vesojen tyviosat mullattiin ja tutkittiin niiden juurenmuodostusta. Aineistosta valittiin 10 kloonia. Näistä yhden juurenmuodostus oli selvästi parempi kuin muiden. Tämä klooni sai merkinnän Mb 4 (*Malus baccata 4*). Nyt se merkitään YP:llä (lyhennys nimistä Yltöinen, Piikkiö).

YP:n talvenkestävyys on erityisen hyvä. Pakkasenkestävyystesteissä sekä lumettomalla koekentällä että laboratoriossa YP on osoittautunut huomattavasti paremmaksi kuin meillä yleisesti käytetty ruotsalainen A 2-klooni sekä englantilaiset M- ja MM-perusrungot.

Perusrungon kasvunvoimakkuutta on tutkittu välillisesti selvittämällä siihen varrennettujen jalolajikkeiden kasvunvoimakkuutta. Viiden ja kahdeksan vuoden kuluttua istutuksesta on YP-runkoon varrennettujen puiden rungon läpimitta ollut suunnilleen sama tai vähän pienempi kuin

A 2-perusrunkoon varrennettujen puiden. YP voidaan näin ollen lukea voimakaskasvuisiin perusrunkoihin.

Myöhäissatoisten 'Alice' ja 'Åkerö' lajikkeiden YP:hen varrennetut puut ovat tuottaneet aikaisemmin satoa kuin A 2-perusrunkoon varrennetut. YP-perusrungolla kasvavat puut ovat yleensä satoisuudeltaan olleet vähintäin samaa luokkaa kuin A 2:lla kasvavat. Joissakin tapauksissa satoisuus on ollut YP:llä parempi, johtuen ilmeisesti paremmasta talvenkestävyydestä. Omenien koko ja laatu on ollut hyvä YP-perusrungolla kasvavissa puissa. Muutamat lajikkeet; kuten 'Ranger', 'Raike', 'Alice', 'Atlas' ja 'Åkerö' ovat tuottaneet YP:hen varrennettuna enemmän ekstra-omenaa (läpimitta 60 mm tai suurempi) kuin A 2-perusrungolla.

Marjaomenapuun siemenperusrunkojen ja jalolajikkeiden välillä on toisinaan havaittu vieroksumista; perusrunko ja jalolajike eivät ole kasvaneet hyvin yhteen. Tällaista ei ole kuitenkaan havaittu YP-perusrungon ja siihen varrennettujen jalolajikkeiden välillä. Vaikka YP on kasvanut marjaomenapuun siemenestä, se on morfologisesti kuitenkin lähempänä viljeltyä omenaa. Sen täysikasvuinen puu ei ole piikikäs; myös sen omena on marjaomenaa paljon suurempi, noin 2/3 tavallisesta viljellystä omenasta.

YP-perusrunkoa on helppo lisätä vanhaan tapaan multauspenkissä, jossa siitä saadaan vuodessa 5 —8 juurtunutta versoa emorunkoa kohti. Sitä voidaan kasvattaa helposti myös puutumattomista pistokkaista sekä juuren palasista.

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MINERAL WOOL AS A GROWING SUBSTRATE FOR GREENHOUSE CUCUMBER

VUOKKO VIROLAINEN

VIROLAINEN, V. 1977. **Mineral wool as a growing substrate for greenhouse cucumber.** Ann. Agric. Fenn. 16:97—102. (Agric. Res. Centre, Inst. Hortic., SF-21500 Piikkiö, Finland.)

According to the research of the Institute of Horticulture, greenhouse cucumber can be grown in mineral wool substrate in Finland. When the 'Landora WW' variety of greenhouse cucumber was grown in a mineral wool substrate, the yield was bigger than that obtained from peat. Bigger yields of the 'Astrid BS' and 'Hama Sv' varieties were obtained from peat basin and peat bed than from mineral wool. At first mineral wool was colder, but in the course of the growing season the temperature differences diminished.

Greenhouse cucumber in the peat basin needed 26 % more water than the plants in mineral wool. Mineral wool growing gave a longer yielding season because the roots survived longer than in peat.

Index words: vegetable, greenhouse cucumber, mineral wool.

In the other Nordic countries mineral wool is in general use as an easyly managed growing substrate (JONSSON 1975) and from there the practice has spread to Finland, as well.

Mineral wool is not a completly inactive material, since it provides small amounts of Ca, Mg, and Na, especially at the beginning of the growing period. The nutrient it supplies to the plants differs from that provided by peat in that the mineral wool lacks the ionizing ability and buffering property. Hence fertilizers must be given in appropriate form and quantity. Since an insufficient or an excessive use of fertilizer can easily by corrected by changing the concentration of the fertilizing solution, the nutrient content should be controlled frequently (HAUPT JØRGENSEN 1976). The number of watering times per day depends on thickness of the plate (HAUPT JØRGENSEN et al. 1976). When the mineral wool plates were the same breadth a thickness of 7,5 cm or 10 cm made no great difference to the quantity of the yield (JONSSON 1976). A plate thicker than 10 cm is not desirable, because the capillary attraction of water is 3—4 cm and thus the upper layers of the mineral wool can become too dry (HAUPT JØRGENSEN 1976). The porous structure of the mineral wool helps to promote the supply of water for the plants. The proportion of pores in mineral wool is 97 % and in good peat 96 %, but the structure of peat weakens during the growing period in long-term cultivations (BLAADJERG 1976).

Some difficult problems in growing

greenhouse cucumber in mineral wool are caused by the fungi *Pythium, Mycosphaerella citrullina* and *Botrytis cinerea.* A layer of algae, which soon forms on the mineral wool, provides an excellent growing ground for the larvae of *Sciara* sp. By not using ammoniumnitrogen in the nutrient solution, by seeing that the plants have sufficient Ca, Mg and K and by taking care of the ventilation and fertilization, it is possible to control the problem of the *Pythium* — fungi in the growing of cucumber. It is good if the pH and solute salt do not change very quickly during the period of growing (NILSSON 1976).

As above shows, mineral wool differs essentially from peat, which is widely used in Finland as a growing substrate in greenhouses. In cucumber growing there has been abundant evidence of root disturbances during the past few years. Therefore attempts have been made to investigate the possibilities of using mineral wool in the growing of cucumbers.

MATERIAL AND METHODS

In 1976 an experiment to investigate the use of mineral wool as a substrate for greenhouse cucumber was started at the Institute of Horticulture. On Jan. 29th 1976, seeds of greenhouse cucumber, — varieties 'Landora WW', 'Hama Sv' and 'Astrid BS' — were sown in mineral wool blocks coated with black plastic and in paper pots containing peat. The mineral wool plates, (7,5 cm thick), were placed horizontally side by side on plastic, in such a way that the surface of the peat and that of the mineral wool were on the same level. The peat basin had a 15 cm layer of peat on plastic. The plants were bedded on March 5th at distances of 75 × 60 cm. Plant density was then 1,5 plants/m^2.

During the growing season the cucumber was fertilized with nutrient solution that was made according to the instructions of Danis Company, the manufacturer of the mineral wool. In the nutrient solutions the total amount of nitrogen was 4 %, of P_2O_5 1,9 % and K_2O 5,4 % and the ratio $NO_3 : NH_4$ was 90 : 10. The peat bed was fertilized according to the soil analysis, and the peat basin according to the peat basin programme of Professor Puustjärvi (PUUSTJÄRVI 1976). To discover the relative proportions of nitrate nitrogen and ammonium nitrogen fertilizing solutions were used where the nutrient concentration was the same except for $NO_3 : NH_4$, which was 90 : 10 and 50 : 50. For the latter experiment the 'Astrid BS' cucumber variety was sown on March 9th and bedded on April 3th in the same way as above.

During the growing season all leaves and shoots below 60 cm were removed. Above this, the shoots were cut behind the first leaf and, above 150 cm, behind the second leaf. Steam cucumbers were grown with 1 cucumber/3 leaves. In both experiments the temperature at night was 19—20°C and in the daytime 22—26°C, in the hot weather even higher.

RESULTS AND DISCUSSION

The effect of mineral wool substrate on the greenhouse cucumber yield

The total yield of the 'Landora WW' variety of greenhouse cucumber was bigger from the mineral wool than from the peat bed or peat basin, but the early yield was smaller than that from the other substrates (Table 1). The yield of 'Hama Sv' and 'Astrid BS' varieties were smaller from the mineral wool substrate than from the peat bed and peat basin. At the beginning of the growing season in Janyary—February, there was a fertilizing disturbance in the mineral wool substrate which was reflected

Table 1. The effect of different plots on yield of greenhouse cucumber in 1976.

Treatment	*Total yield kg/m²	**Early yield kg/m²	First quality in weight per cent %	Weight of a fruit g
Peatbench:				
'Landora WW'	37,7	17,3	83,0	418
'Hama Sv'	43,3	19,3	78,1	407
'Astrid BS'	44,4	17,9	81,3	430
Peatbasin:				
'Landora WW'	40,0	14,8	78,4	415
'Hama Sv'	46,1	17,3	86,1	419
'Astrid BS'	44,5	15;0	80,5	419
Mineralwool:				
'Landora WW'	40,2	13,0	81,7	424
'Hama Sv'	35,1	9,3	80,0	436
'Astrid BS'	35,2	10;4	83,2	419
*29/3 – 15/9				
**29/3 – 31/5				

in the yield. The effect of the disturbance diminished later and the yield of the different plots began to be more equal. From May on, the yields of the 'Landora WW' variety were larger in the mineral wool substrate than in the peat plots. The monthly yields of the 'Astrid BS' and 'Hama Sv' varieties grown on the mineral wool were not as big as the yields in the peat basin (Table 2). The dry-material content of fruits seemed to vary from 3,6 % to 4,2 % on May 23th and on August 26th in 1976 (Table 3). In this experiment the quality of the substrate seemed to have no significant effect on the quality of the fruits (Table 1). The yield was graded according to the current quality requirements.

Table 3. The Effect of different plots on the dry material content of greenhouse cucumber varieties 'Landora WW', 'Hama Sv', 'Astrid BS' on an average on May 23 th and on August 23 th in 1976.

Date	Dry material content		
	Peabench %	Peatbasin %	Mineralwool %
23/5	4,2	4,0	4,2
26/8	4,1	3,8	3,6

The temperature of the mineral wool substrate

Differences were found to occur in the temperatures of the growing substrates, although the pipes, at a depth of 20 cm, were kept at an even temperature. E.g. in March, the morningtemperature of the peat bed was 4—6°C, and that of the peat basin 2—3°C, higher than that of the mineral wool. Burning was active in the peat bed and the heat could rise freely to the surface. In the peat basin and mineral wool, the plastic prevented the heat from rising from the pipelines and from the peat

Table 2. The effect of different plot on monthly yield of greenhouse cucumber varieties 'Landora WW', 'Hama Sv', 'Astrid BS' in 1976.

Treament	April kg/m²	May kg/m²	June kg/m²	July kg/m²	August kg/m²	Sept. kg/m²
Peatbench:						
'Landora WW'	7,6	9,6	9,5	5,2	4,5	1,3
'Hama Sv'	7,5	11,8	10,9	6,8	5,3	1,0
'Astrid BS'	8,6	10,7	6,5	7,6	7,6	1,7
Peatbasin:						
'Landora WW'	7,0	7,8	11,0	6,0	6,1	2,1
'Hama Sv'	6,2	11,1	10,9	7,5	7,8	2,6
'Astrid BS'	6,6	8,4	10,2	8,2	7,3	3,3
Mineralwool:						
'Landora WW'	3,1	9,9	10,3	7,2	7,1	2,6
'Hama Sv'	2,5	6,8	10,4	6,4	6,8	2,1
'Astrid BS'	3,3	7,1	9,3	6,6	6,5	2,4

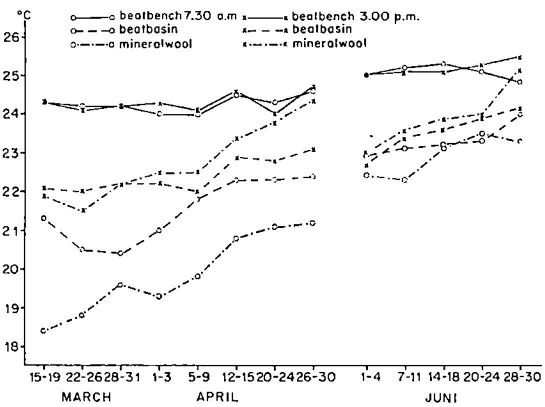

Fig. 1. The temperature in the various substrates in March, April and June in 1976. Temperatures are measured at a depth of 4 cm at 7,30 a.m. and 3.00 p.m.

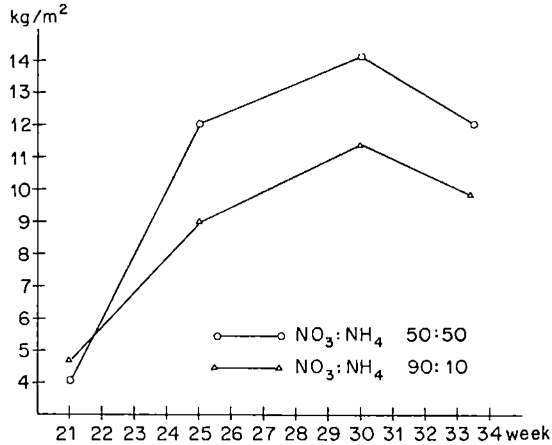

Fig. 2. The effect of nutrient solutions, in which $NO_3 : NH_4$ was 90 : 10 and 50 : 50, on the yield of 'Astrid BS' variety in 1976.

burning at the bottom. The temperature variations diminished in the afternoons when the sun warmed the surface of the plots. From June onwards there were no great variations in the temperature, because the burning of the peat decreased and a layer of dark-coloured algae, that had developed on the mineral wool, absorbed the head (Fig. 1). Temperatures in the mineral wool blocks coated with black plastic rose higher than in the paperpots. In the plastic coated cubes the temperature exceeded 30°C. So high a temperature increases the roots susceptibility to disease and encourages the spreading of fungi that cause plant diseases (NILSSON 1975).

The watering and fertilization of mineral wool

When the 7,6 cm plates were placed side by side, the roots of the cucumber grew from one plate to another. In this case watering twice a day was found to be sufficient, because no wilting occurred in the daytime. The amount of water was about 26 % less than was used in the peat basin. NH_4 -nitrogen in the nutrient solution is said to have a greater effect than NO_3 -nitrogen in increasing the plant susceptibility to disease (NILSSON 1976). This was not observed in the present experiment, which, however, showed differences in the yield. When the $NO_3 : NH_4$ of nutrient solution was 50 : 50, the yield was 22 % more than when the $NO_3 : NH_4$ was 90 : 10 (Fig. 2).

The effect of the mineral wool substrate on the roots of cucumbers

In the peat substrate, root disturbances occurred earlier and more frequently than in the mineral wool (Table 4). In this experiment it was noted that the structure of the peat became denser but

Table 4. The effect of different plots on the roots of greenhouse cucumber on October 1th in 1976.

Treatment	Dead %	Injured %	Sound %
Peatbench:			
'Landora WW'	58	33	9
'Hama Sv'	75		25
'Astrid BS'	33	50	17
Peatbasin:			
'Landora WW'	50	25	25
'Hama Sv'	33	50	17
'Astrid BS'	50	9	41
Mineralwool:			
'Landora WW'	9	33	58
'Hama Sv'	55		45
'Astrid BS'	26	16	58

the mineral wool remained unchanged. Fungi such as *Rhizotonia, Fusarium, Botrytis cinerea* and *Penicillium* were found in the peat, and *Fusarium* and *Rhitzotonia* in the mineral wool, as analysed by the Institute of Plant Patology. When a plant in the mineral wool died the one next to it soon wilted. Mineral wool is comparable to steamed peat in that fungi, once they appear in it spread quickly, having no rivals (NILSSON 1975). A layer of algae soon appeared on the mineral wool, forming an excelent growing ground for the larvae of *Sciara* sp., as analysed by the Institute of Pest Investigation. From August onwards, damage caused by these larvae could be seen in the roots of the cucumber in the mineral wool plots.

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SELOSTUS

Kivivilla kasvihuonekurkun kasvualustana

VUOKKO VIROLAINEN

Maatalouden tutkimuskeskus

Puutarhantutkimuslaitoksessa vuonna 1976 suoritetussa kokeessa selvitettiin kasvihuonekurkun viljelyä kivivillakasvualustalla. Tutkimuksessa pyrittiin selvittämään voitaisiinko kivivillaa kasvualustana käyttäen löytää ratkaisu kasvihuonekurkun fysiogeenisiin ja patogeenisiin juuristohäiriöihin.

Kasvihuonekurkkulajikkeet 'Landora WW', 'Hama Sv' ja 'Astrid BS' kylvettiin tammikuun alussa kivivillakuutioihin sekä paperipotteihin turvepeti ja turveallas vertailua varten. Kun taimet istutettiin maaliskuun alussa, niiden tiheys oli 1,5 tainta/m^2. Kasvukauden aikana kivivillaan istutettuja kurkkuja lannoitettiin ravinneliuoksella, joka sisälsi 4 % N, 1,9 % P_2O_5 ja 5,4 % K_2O. Turvepeti lannoitettiin maa-analyysien mukaan ja turveallas professori Puustjärven ohjelman mukaan.

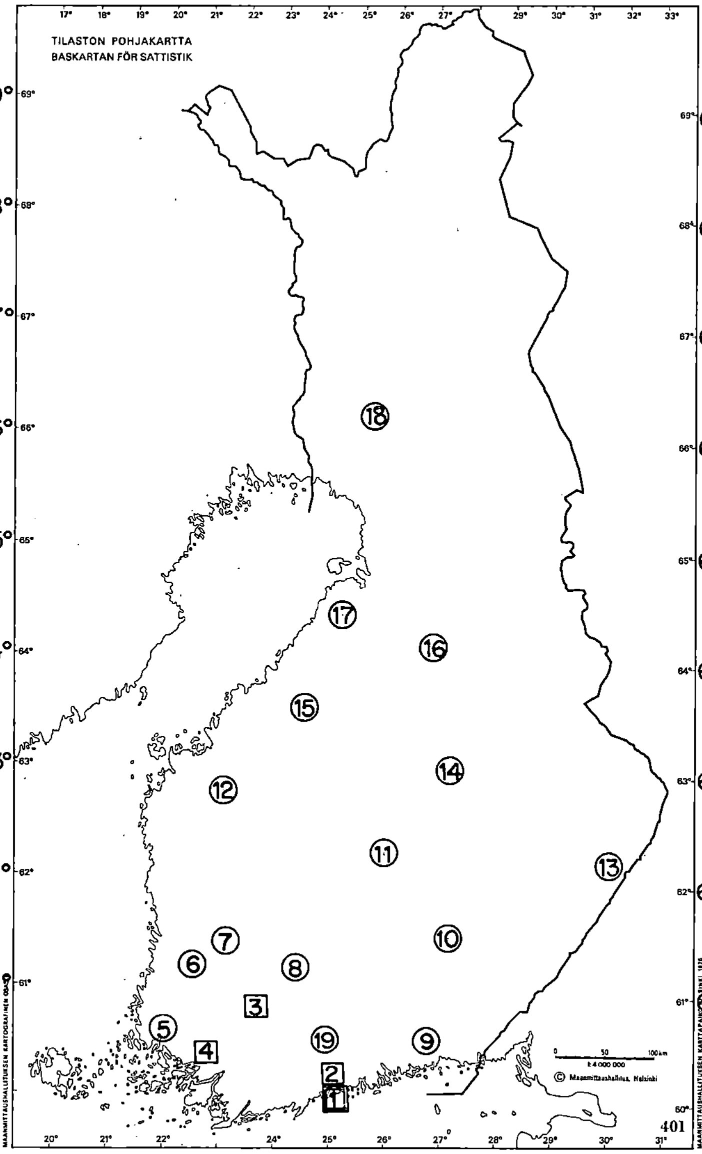
Nitraatti- ja ammoniumtypen suhteen selvittämiseksi lannoiteliuoksessa käytettiin liuoksia, joissa ravinnepitoisuudet olivat muuten samat, paitsi NO_3:NH_4 oli 90 : 10 ja 50 : 50. Lämpötila oli öisin 19—20°C ja päivisin 22—26°C.

'Landora WW' -lajiketta lukuun ottamatta kasvihuonekurkkujen kokonaissato jäi kivivillassa alhaisemmaksi kuin turvepetissä ja turvealtaassa. Kasvukauden alussa sattunut lannoitehäiriö alensi varhaissatoja kivivillassa kasvaneessa kurkussa. Lajikkeesta 'Landora WW' saatiin kivivilla-alustalla toukokuusta lähtien runsaammin satoa kuin turvepetistä ja lajikkeista 'Hama Sv' ja 'Astrid BS' vasta kasvukauden lopulla. Turvealtaan satoa eivät nämä kaksi lajiketta kivivillassa saavuttaneet, mutta lajike 'Landora WW' antoi heinäkuusta lähtien runsaammin satoa kivivilla-alustalta kuin turvealtaasta. Edellä mainituilla alustoilla kasvaneiden kurkkujen kuiva-ainepitoisuus vaihteli 4,2 prosentista 3,6 prosenttiin. Mittaukset suoritettiin touko- ja elokuussa.

Kasvukauden alussa ja aamuisin kivivillan lämpötila oli alhainen. Esimerkiksi maaliskuussa turvepetin lämpötila oli jopa 4—6 astetta ja turvealtaan noin 2—3 astetta korkeampi kuin kivivillan. Vilkas bakteeritoiminta kehitti turpeessa lämpöä. Kivivillan pinnalle muodostunut leväkerros keräsi auringon säteilylämpöä ja huhtikuusta lähtien iltapäivisin lämpötila kohosi lähelle turvepetin tasoa ja korkeammaksi kuin turvealtaan. Mustalla muovilla päällystetyissä kuutioissa lämpötila nousi juuristolle vaarallisen korkeaksi.

Levyn paksuudesta riippuu kastelukertojen määrä vuorokaudessa. Tässä kokeessa 7,5 cm paksuinen levy oli kasvihuonekurkulle sopiva, kun kasteltiin kaksi kertaa vuorokaudessa. Kasteluveden määrä jäi 26 % alhaisemmaksi kivivillassa kuin turvealtaassa. Kun ravinneliuoksen $NO_3 : NH_4$ oli 50 : 50 saatiin 22 % runsaammin satoa kuin $NO_3 : NH_4$ oli 90 : 10.

Juuristohäiriöitä esiintyi aikaisemmin ja runsaammin turvekasvualustoilla kuin kivivillassa.



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