Table 4. The effect of cold exposure in the laboratory on cambial browning and growth in the field of 'Juneprince'/Lovell peach trees.

Temperature[z] (C)	Cambial Browning[y]		Cumulative tree dry wt. (g)[v]	
	Jan. 93[x]	Feb. 93[w]	Stem	Stem + roots
- 9	1.0 c[u]	1.2 c	558 a	975 a
-12	1.0 c	1.0 c	397 a	695 a
-15	1.0 c	1.2 c	383 a	800 a
-18	1.2 c	1.6 c	(dead)	(dead)
-24	2.6 b	3.6 b	(dead)	(dead)
-30	4.2 a	5.6 a	(dead)	(dead)
-35	4.8 a	5.8 a	(dead)	(dead)

[z]Cold treatment, 11-15 Jan. 1993.
[y]Cambial browning scale: 1 = none, 6 = severe browning. Rating taken at midpoint between graft union and terminal.
[x]Trees in subsample 1 were rated the day following cold treatment.
[w]Trees in subsample 2 were rated ≈ 4 weeks after cold treatment.
[v]Trees in subsample 3 were planted 30 Mar. and grown until 24 Nov. 1993.
[u]Mean separation by Duncan's multiple range test. Values in columns followed by the same letter are not significantly different at $P \leq 0.05$.

Literature Cited

1. Cain, D. N. and R. L. Anderson. 1979. Relative freezing injury to 'Velvet,' 'Redhaven,' and 'Siberian C' peaches following controlled freezer tests at selected dates during two winters. J. Amer. Soc. Hort. Sci. 104:839-843.
2. Stergios, B. G. and G. S. Howell, Jr. 1973. Evaluation of viability tests for cold stressed plants. J. Amer. Soc. Hort. Sci. 98:325-330.
3. Yadava, U. L., S. L. Doud, and D. J. Weaver. 1978. Evaluation of different methods to assess cold hardiness of peach trees. J. Amer. Soc. Hort. Sci. 103:318-321.
4. Yadava, U. L., S. L. Doud, and D. J. Weaver. 1984. Rating scales to assess cold injury and bacterial canker development in peach trees in the field. HortScience 19:645-648.

Fruit Varieties Journal 50(4):229-235 1996

Root System of Plum Trees on Standard and Dwarfing Rootstocks

A. S. DEVYATOV[1]

Abstract

Root mass and root distribution of 'Edinburg' plum trees, grafted on clonal rootstock VVA-1 (hybrid of *Prunus tomentosa* and *P. cerasifera*), rooted stem cuttings of *Prunus tomentosa*, and seedlings of *P. cerasifera*, were studied to the depth of one meter in sod-podzolic soil. Trees on VVA-1 and *P. tomentosa* rootstocks were 1.5 to 3 times smaller than on *P. cerasifera*. The root system of *P. tomentosa* was very weak. Specific mass of fibrous roots of VVA-1 was twice that of *P. cerasifera*. Yield efficiency of 'Edinburg' trees on rootstock VVA-1 was twice that of trees on *P. cerasifera*.

Introduction

Production of high density plantings of plum in modern orchards has increased interest in dwarfing plum rootstocks. Putov (8, 9) first produced such rootstocks at the Altay Research Station (Barnaul, Altay region, Russia). A dwarfing rootstock Pixy was introduced by the East Malling Research Station (11, 12, 14, 15). High yields of plum trees grafted on seedlings of *Prunus tomentosa* (*Microcerasus tomen-*

[1]The Byelorussian Research Institute for Fruit Growing, Samokhvalovichy, 223013 Minsk, Belarus.

tosa (Thumb.) Erem. et Iushev), the Manchu cherry, were reported from the Ukraine (13). Eremin (6) developed VVA-1, a hybrid between *P. tomentosa* and *P. cerasifera* as a dwarfing clonal rootstock for plum and it was reported to perform well in orchard trials. But information on root systems of dwarf plum rootstocks is limited (1, 10).

Materials and Methods

'Edinburg,' a *P. domestica* cultivar, was grafted on 1) VVA-1 clonal rootstock; 2) *P. tomentosa* clonal rootstock; 3) seedlings of *P. cerasifera*. Rootstocks of VVA-1 and *P. tomentosa* were propagated by stem hardwood cuttings. Seedlings of *P. cerasifera*, the main plum rootstock in East Europe (5) were grown from local trees. Six year old trees planted at 5 x 3 m were excavated. Orchard floor was clean cultivated by disking to the depth of 8-10 cm. Herbicides were used in the tree row every year by strip of 2 m.

Trees were grown in a sod-podzolic silty loam soil formed in a loess. Soil horizons were as follows. A_1 0-22 cm. light gray, lumpy-silty, top clotted, bottom foliate; A_2B_1 22-48 cm, brown, silty loam; B_2 48-100 cm, brown with within thin layers, silty loam, bottom loamy sand, nut-like, moist, hard, and compacted. Bulk density at the depth of 3-6 cm was 1.22 $g.cm^{-1}$, 13-16 cm 1.44 $g.\ cm^{-1}$, and in horizons B_1 and B_2 1.50 and 1.57 $g.\ cm^{-1}$, respectively. Field capacity was near 22% of soil weight. Air porosity at field capacity in horizon B was more than 14% of soil volume. The soil water table was at a depth of 4 to 5 m below the surface. The A horizon contained near 1.5 to 2% humus and sufficient amounts of nitrates (near 1-4 mg NO_3 per 100 g of soil). The quantity of humus decreased to 0.2-0.3% in the B_2 horizon. There were sufficient quantities of phosphorus (20-25 mg P_2O_5) and potassium (8-15 mg K_2O) per 100 g of soil in the A horizon and half of this amount in the two B horizons.

Root excavations were carried out on 6 year old trees using a modified monolith method (2, 7) used previously on root investigations of pear trees (3). The experimental plum tree plots were chosen in different parts of the orchard. Each plot contained 2-3 trees located in adjacent rows. A rectangle of 4 x 0.5 m was laid out between the trees at a distance of 0.5 m from their trunks, perpendicular to tree row. This rectangle was divided into 8 squares, with 0.5 m sides, root samples were collected on two trees in adjacent rows. A rectangle for root excavation of one tree had a length of 2 m and was divided into four squares. Monoliths of a thickness of 0.1 m were taken out from each square to the total depth of 1 m. All roots were collected from each monolith, washed free of soil, surface dried and graded according to the thickness into two fractions: 2 mm and smaller designated as fibrous roots and 2.1 mm and greater designated as scaffold roots. These fractions have identical root anatomy, but fibrous roots are main carriers of absorptive roots. Each root fraction was weighed; the length of scaffold roots were determined.

Four replications of each rootstock were excavated.

Table 1. Growth and yield of plum trees on different rootstocks.

Rootstock	Trunk cross sectional area (cm^2)	Canopy height (m^2)	Cumulative yield for years 4-6 (kg/tree)	Yield efficiency (kg/cm^2 trunk)
VVA-1	20a*	3.8	21a	1.05
P. tomemtosa	54b	6.7	34b	0.63
P. cerasifera	86c	8.8	49c	0.57

*The means within columns followed by unlike letters are significantly different according to LSD_{05}.

Tree growth and yield were determined at the same plot where trees were excavated. Trunk cross section area was calculated on the base of circumference of trunk above the graft union.

All experimental data were calculated per m^3 for finding of specific indices of root weight or root length ($g \cdot m^{-3}$ or $m \cdot m^{-3}$). Statistical methods were used for calculation of LSD05 (4).

Results

Tree growth and fruiting.

Tree growth was greatly influenced by the rootstocks. (Table 1). Trees on rootstock VVA-1 had a trunk cross sectional area one-fourth and canopy height half as high as trees on *P. cerasifera*. Yield efficiency (yield per cm^2 of trunk cross area) of trees grafted on VVA-1 was 80% greater than on *P. cerasifera*. The size of trees on *P. tomentosa* was intermediate between those on the other two rootstocks. Fruiting of trees on *P. tomentosa* was poor.

Root system vigour.

The specific length of scaffold roots ($m \cdot m^{-3}$) of trees on dwarf rootstock VVA-1 was the same as that of trees on *P. cerasifera* in the soil layer 0-100 cm (Table 2). However, scaffold roots of VVA-1 branched more than *P. cerasifera*. This resulted in 25% less specific root mass of VVA-1 than *P. cerasifera*. Scaffold roots of VVA-1 were thinner and had lesser specific mass down all soil profiles. The thickness of scaffold roots of VVA-1 averaged 35% less than *P. cerasifera*.

In contrast, the specific mass of fibrous roots of VVA-1 was 84% more than that of *P. cerasifera* in the top 1 m soil layer.

All root indices of *P. tomentosa* were less than those of VVA-1 or *P. cerasifera* (Table 2, Fig. 1). The specific length of scaffold roots of trees on *P. tomentosa* in the 1 m soil layer was one-third that of the other two rootstocks and the specific mass of these roots was 7 and 9 times smaller than that of VVA-1 and *P. cerasifera*, respectively.

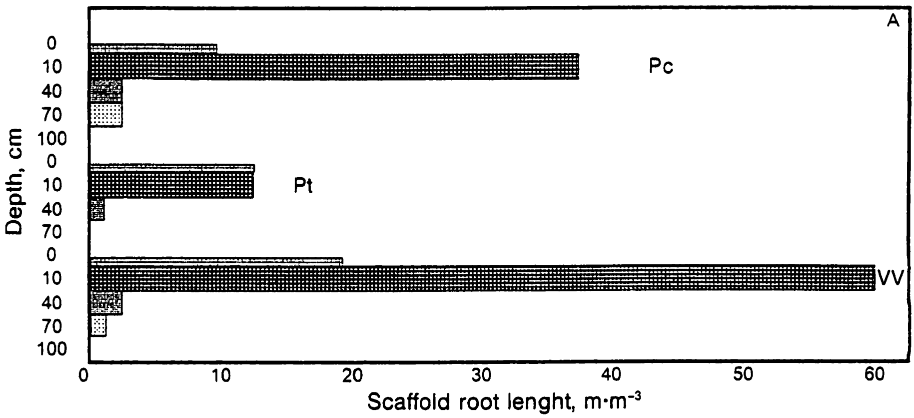
The horizontal distributions of the roots radiating out from the trunk position were uneven (Fig. 1). Scaffold roots were concentrated in an area 0.5 to 1 m from the trunk. About 40% of scaffold root length and 40-60% of scaffold root mass was located here. The rootstock VVA-1 and *P. tomentosa* had very few scaffold roots as far as 2 m from the trunk whereas *P. cerasifera* produced 14% of its scaffold root length at that distance from the trunk.

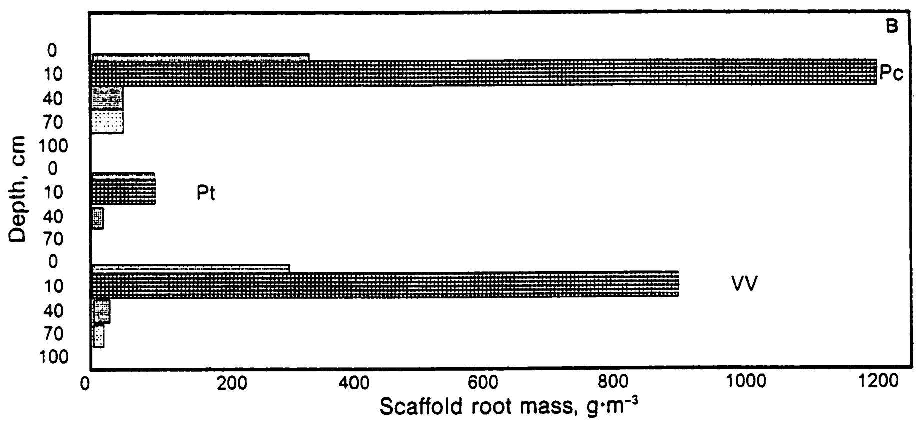
There were substantial differences between rootstocks in the distribution of fibrous. roots. The mass of fibrous roots of VVA-1 rootstock in the monoliths located near the tree trunk was almost 3 times more than in the monoliths located in the mid row position. Trees on *P. tomentosa* rootstock had the least quantity of fibrous roots ($g \cdot m^{-3}$) near the trunk and in the middle of between row strip. *P. tomentosa* rootstock had its fibrous roots located at the periphery of the canopy, but on the whole the distribution of fibrous roots was more uniform than the other two rootstocks. The specific mass ($g \cdot m^{-3}$) of fibrous roots of *P. cerasifera* increased constantly in a radial direction (Fig. 1). With this rootstock most

Table 2. Total root length and fresh weight per m^3 of soil excavated from top one meter. The mean for monoliths at the distances of 0.5-1 m, 1-1.5 m, 1.5-2 m and 2-2.5 m from the tree trunk.

Root Index	VVA-1	*P. tomentosa*	*P. cerasifera*
Length of scaffold roots, $m \cdot m^{-3}$	14.3a*	4.7b	14.0a
Mass of scaffold roots, $g \cdot m^{-3}$	314b	47a	424c
Mass of fibrous roots, $g \cdot m^{-3}$	118a	38c	64b

*The means with unlike letters along line are significantly different according to LSD_{05}.





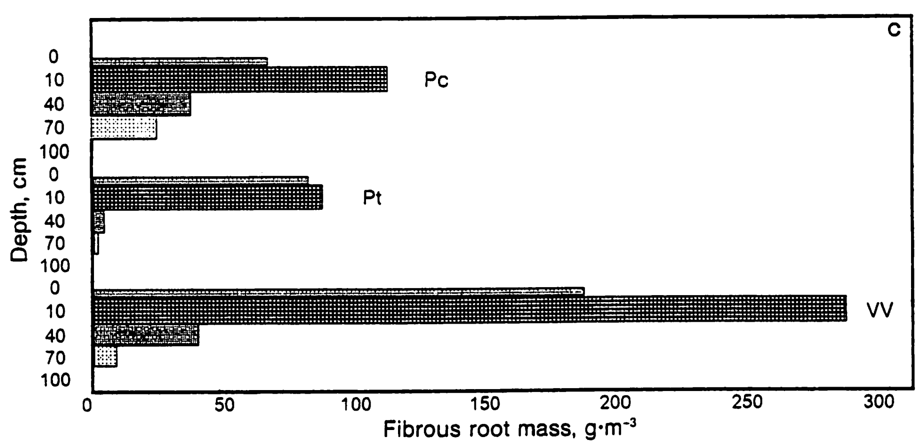


Figure 1. Distribution of specific scaffold root length, scaffold root mass and fibrous root mass in horizontal direction out from the tree trunk to the depth of 1 m. Rootstocks: Pc = *P. cerasifera;* Pt = *P. tomentosa;* VV = VVA-1.

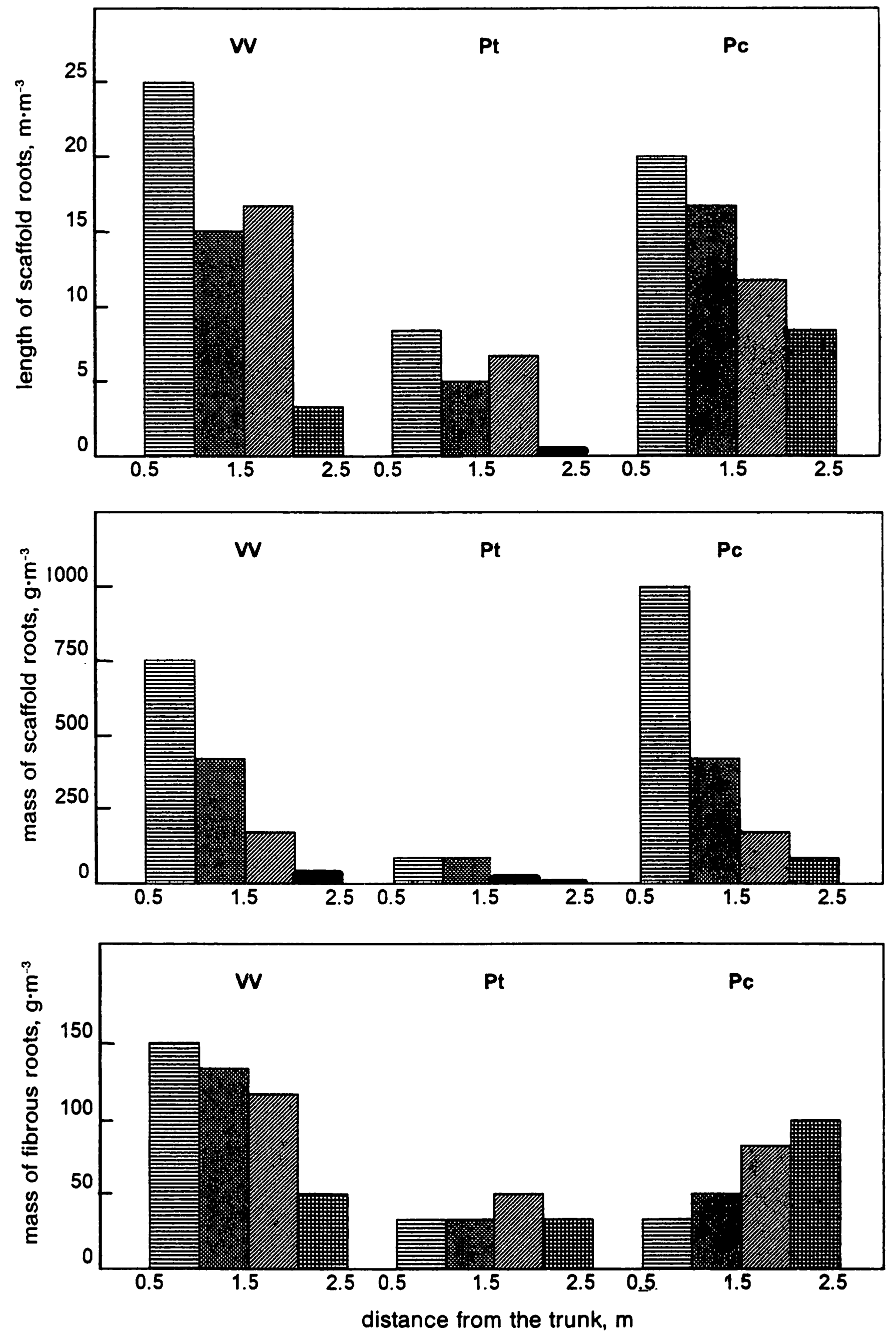


Figure 2. Distribution of specific scaffold root length (A), scaffold root mass (B) and fibrous root mass (C) down the soil profile (depths 0-100 cm), Rootstocks: Pc = *P. cerasifera;* Pt = *P. tomentosa;* VV = VVA-1.

fibrous roots were located 2.0-2.5 m from the trunk. The specific mass of fibrous roots of this rootstock, at the distance from 0.5 to 1 m from the trunk, was half of that from samples 1.5 to 2.5 from the trunk.

Rootstocks differed also in where the roots developed in the soil profiles (Fig. 2). *P. cerasifera* roots were located deeper. Only 75% of the scaffold root length *P. cerasifera* were in the top 30 cm of soil compared with 91% of VVA-1. It is important to note that in the layer from 30 to 40 cm the specific scaffold root length of VVA-1 was 5 times lower than that on *P. cerasifera*. However at the depth of 0-10 cm it was 2 times and in the 10-40 cm layer—1.7 times greater than *P. cerasifera*. Specific mass of fibrous roots of VVA-1 rootstock in the layer 0-100 cm was 84% greater than the other rootstocks, but in the layer of 0-10 cm it exceeded *P. cerasifera* 3 times and on the depth of 10-40 cm 2.4 times.

Discussion

Growth of 'Edinburg' was greatly influenced by choice of rootstock. Trunk cross section area of the 6 year old trees on VVA-1 and on Manchu cherry *(P. tomentosa)* was 23 and 63%, respectively, of trees on myrobalan *(P. cerasifera)*. In spite of these great differences in growth the early yields differed only slightly and the cumulative yield was more similar than the growth. This greatly increased the efficiency indices of trees on the rootstock VVA-1 which were twice those trees on *P. cerasifera*.

Despite the difference in the above ground vigour and growth, the length and mass of scaffold roots of trees on VVA-1 and *P. cerasifera* were roughly equal and both were 3 times more than the scaffold root length of trees on *P. tomentosa*. Clearly, the most dwarfing rootstock, VVA-1, had the most fibrous roots, 56% more than *P. cerasifera* and 68% more than *P. tomentosa*. A similar phenomenon, of strong growth of fibrous roots on dwarfing rootstocks, was noted in M.9 rootstock of apple (11).

Some researchers have noted profuse suckering of trees grown on *P. tomentosa* (8) but this did not happen in our trial. Some reports in the literature indicate acceptable compatibility of *P. tomentosa* with standard cultivars of plum (13). However, we observed some signs of incompatibility of *P. tomentosa* with 'Edinburg' in our trials.

High concentrations of roots near to the trunk of plum trees grafted on VVA-1 rootstock and the very dwarf trees that developed on this rootstock indicate that this rootstock may be useful for high density plum plantings. The small trees produced on VVA-1 allow sufficient light penetration into the canopy and the roots close to the tree do not utilized large soil resources. Therefore, it is estimated that 2000 to 2500 plum trees could be planted per ha on this rootstock. This would allow a great increase in productivity and improvements in yield precocity. In addition, the roots of this rootstock were not damaged by the severe 1993-94 winter when roots of a nearby strawberry plantation suffered severe injury.

Literature Cited

1. Atkinson, D. 1980. The distribution and effectiveness of roots on tree crops. Hort. Rev. Ed. J. Janick. 424-490.
2. Devyatov, A. S. 1985. Increase of Quality of Fruit Trees and Yield of Orchards. 2nd ed. Urozhai, Minsk. In Russian.
3. Devyatov, A. S. 1993. Comparison of root development of pear trees on seedling and quince A and C rootstocks. Fruit Var. J. 47:193-197.
4. Dospekhov, B. A. 1985. Methods of the Field Experiment. 5th ed. Agropromizdat, Moscow. In Russian.
5. Eremin, G. V. 1989a. Mirobalan. Agropromizdat, Moscow. In Russian.
6. Eremin, G. V. 1989b. Distant Hybridization of Stone Fruit Plants. Agropromizdat, Moscow. In Russian.
7. Kolesnikov. V. A. 1971. The Root System of Fruit Plants. Mir Publ. Moscow.

8. Putov, V. S. 1978. Plum breeding at the Altay. In: V. S. Putov (ed.) Breeding and Technology of Fruit Crops. Kolos, Moscow. In Russian.
9. Putov, V. S. 1981. Breeding of clonal plum rootstocks at the Altay. Sbornik Nauch. Trud. 34:71-75. In Russian. Also in Hort. Abstr. 54:3257. 1984.
10. Tamasi. J. 1986. Root Location of Fruit Trees and Its Agrotechnical Consequences. Budapest.
11. Tatarinov, A. N. 1988. Fruit Growing on Clonal Rootstocks. Urozhai, Kiew. In Russian.
12. Tatarinov, A. N. 1989. Clonal Rootstocks of Stone Fruit Trees. Agropromizdat, Moscow. In Russian.
13. Tretiak, K. D. 1983. Dwarf plum rootstocks. Sadowodstwo 1:23-24. In Russian.
14. Webster, A. D. 1980a. Dwarfing rootstocks for plums and cherries. Acta Hort. 114: 201-207.
15. Webster, A. D. 1980b. Pixy, a new dwarfing rootstock for plums, *P. domestica* L. J. Hort. Sci 55:425-431.

Fruit Varieties Journal 50(4):235-247 1996

Clone Selection of Grape Vine Varieties in Germany

HAROLD SCHÖFFLING[1] AND GÜNTHER STELLMACH[1]

Abstract

In Germany, clonal selection based on plant performance is a 200 year-old tradition. The present program, 'Systematic preservation-breeding' of varieties is a legally established system and is based on careful individual plant selection with subsequent biometrical tests on descendants (clones). First characteristics of about 10,000 vines were observed for five years. Thereafter the number of individual vines per clone was approximately 100 in every test. Must density, total acidity and ph-value were determined with sample of berries and yield determined from number of bunches, number of berries per bunch as well as their average weight. Statistical evaluation of the initial results in the individual vine selection consisted of the four field method. The main procedure for systematic maintenance of clonal varieties consisted of a complex series of observations and repeated tests. These resulted in A-, B- and C-clones. Basic propagation material came from C-clones. Certified plants came from Basic plants. Besides freedom from leaf-roll disease and ringspot diseases, such as yellow mosaic, virological tests were required on the mother stock plants. Plants were also tested for nepo-viruses, the corky bark pathogen, Rupestris stem pitting and Kober stem grooving. Optimum growth clones were selected which had less vigorous growth but satisfactory yield and quality. For example, a favorable starting position was to select A-clones with up to 20% less growth but good yield levels. Differences in bunch rot resistance among clones was greatest in 'Auxerrois' and least in Pinot noir. A trial with 11 A-clones of Riesling, showed that between the years 1991-1993 the range in portion of fallen bunches, amounted to 190%, and ranged between 9 and 26 kg/acre. Frost resistance clones produced yield decreases of only 25% in frost years; sensitive clones decreased 56%. Investigations into chlorosis-resistance among clones suggested that differences of up to 30% were produced among the 13 Riesling clones. Other resistances may also be worth investigating such as resistance to stem atrophy. When berries were smaller (e.g. clone Weinsberg 29) must density and wine quality increased. The size of the grape yield was determined primarily by the number of bunches. The number of berries per bunch and the individual berry weight were mostly affected by fruit set. Sensory wine assessments from clones growing under the same cultivation conditions produced maximum differences in the nose, in the taste, in harmony and in quality of up to 40%. This demonstrates that some clones produced better wines.

Introduction

In order to preserve the typical characteristics of grapevine varieties in Germany, numerous clones are propagated vegetatively and tested repeatedly to select those without change (unaffected by somatic mutations and/or systemic infections) which can be used profitably by winegrowers. Production using less discriminating plant material can lead to the unrecognized inclusion of somatic negative-

[1]Central Office for Clonal Selection and Federal Biological Research Center of Agriculture and Forestry, Trier and Bernkastle-Kues (Germany).