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Clone Selection of Grape Vine Varieties in Germany

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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-

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mutations as well as systemic infections. This leads to vine stocks which vary in their performance or even fail totally. These negative factors must be eradicated in clones of high value. The work that leads to this is the 'systematic preservation-breeding' of vine varieties. In Germany it is legally established and based on careful individual plant selection with subsequent biometrical tests on the descendants, called clone breeding. This is especially important in 'old' varieties because their original specimens are unknown and therefore not available for propagation. Consequently, pathogen-diagnosis and sanitation procedures, if necessary, must be applied to well-chosen examples of the respective variety, in order to produce infection-free mother plants, which when cloned are to undergo years of genetic valuation tests.

History of Clonal Selection

The first references to selection-propagation of wine producing vines, which are also worth noting from today's point of view, come from Columella (1), who published a comprehensive 12 volume work 'De re rustica' in the year 60 AD. The catalog of his recommendations was aimed at preventing decline of vine performance by selection and propagation of high-yielding individual vines.

A targeted vegetative selection-preservation began with the so called mass selection based upon a decree dated from the year 1787 of Clemens Wenzeslaus, Kurfürst of Trier on the Mosel. The introduction of a scheduled clonal selection was after the appearance of *Uncinular necator* (1850), *Peronospora viticola* (1878) and *Phylloxera vastatric* (1881) in Germany. Gustav Frölich compared fruitful individual vines (FS) of the variety Silvaner, for 16 years from 1876 and selected the winner (18). Using these progenies in 1900 the first clonal vineyard was planted. In 1921 it was recognized by the state as the first 'high breeding vineyard.' Frölich supplied evidence thereby that the fruitfulness of vines is passed on through their vegetative progenies.

In 1925 Friedrich August Frölich expanded the process of clonal selection through progeny-tests and introduced as a result of this the concept of an A-clone (PT, see Figure 1). Seeliger, Baur and Decker refined the breeding methods by expanding the progeny tests to B-clones (IT) and C-clones (MT). The entry of clones in the 'breeding-register for vine varieties,' established in 1953, requires the successful structure of these three breeding phases. This structure plan (Figure 1), introduced in 1937 by Husfeld is still applicable today. It includes, in

Table 1. Nine-year (1987-1995) performance comparison between healthy and virus infecteed plants of Riesling, clone Weis 21, from the research department of the State vineyards at Trier (Mosel).

Health-grade	Grape-yield kg/ar	Must-density °Oe	Total-acidity g/l	pH-value	Grape rot %	Fallen-bunches 1 (low) -3
Infected with Fanleaf (Nepovirus)	60	68	15.1	2.76	13	1.3
Infected with Arabismosaic (Nepovirus)	64	70	15.1	2.75	13	1.3
Infected with Leafroll (Chlosterovirus)	33	69	15.3	2.80	5	1.1
Healthy	68	69	15.3	2.76	12	1.3
Mean value	59	69	15.2	2.77	11	1.2
Max. Diff.	110%	4%	1%	2%	153%	18%

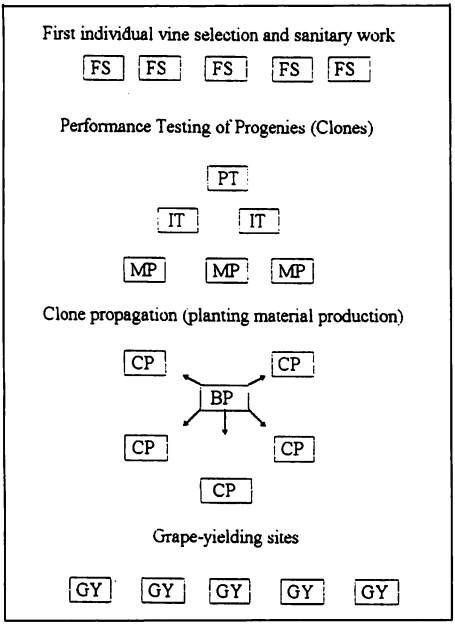

Figure 1. Scheme for the systematic preservation breeding (clonal selection) of grape vine varieties in Germany.

principle, 4 test-phases (FS, PT, IT, MT) for developing a clone, each lasting 5 years. From the last three test-phases the A-, B- and C-clones originate.

In 1926 there were 6,194 ha of State-certified vineyard areas originated from clones. In 1956 the Federal Varieties Office (with headquarters in Hannover) registered 331 clones from 13 grape-producing vine varieties, by 11 private and 9 state clone-breeders. Since 1995 it has been forbidden to plant non-clonal material.

Through the work of Schneiders (12) the scientific world was made aware of the significance of virus diseases in the performance of vegetatively propagated vines. From 1960 onwards, virological tests on selected 'mother' vines were carried out in several laboratories. They began with the production of 'virus-tested' subclones. The names of Bercks, Brückbauer, Rüdel and Stellmach were involved with this development. From 1976 virus-tested propagation sites existed and from 1987 followed State certification of virus tested clones. From 2002 all Basic plant material will be virus tested.

The advances in the fields of pathogen-diagnosis and pathogen-therapy made throughout the world were carefully observed and some laboratories began to use modern biotechnical methods for clonal selection. Discussions about the value of molecular biological methods in pathogen diagnosis as well as about meristem culture and 'healing' propagation in the field of pathogen therapy are still in full swing (20). Likewise, opinion about the value of *in-vitro* propagation of 'healthy' vines for the acceleration and improvement of genetic selection has not been finalized. In an effort to avoid chemicals in the rehabilitation of vines, hot water treatment of unrooted and rooted vines came to the fore.

The Central Office for Clonal Selection (Trier), established in 1967, extended the scientific base for clone breeding. Investigators, such as Weiling (22, 23, 24), utilized statistical analyses as the basis for the research. Contact and discussion with expert colleagues throughout the world were promoted through the 'International Clone Symposium' (held every 5 years) which was founded by Schöffling and Faas in 1971. Since 1989 it was combined with the 'International Symposium on Grape Breeding,' which occurs every 3 years.

Motives for Modern Clonal Selection

The performance capability of wine-producing vines can be impaired by chronic diseases triggered by viruses, bacteria, fungii and mycoplasms. The most important virus-diseases are 'fanleaf' caused by nepo-viruses and 'leaf-roll' caused by clostero-viruses

Table 2. Timetable for carrying out the selection work of grape vine varieties in Germany.

Month	Performance	Health
January	Data evaluation Wine analysis	Wood samples for Indexing Hot water treatment (FD, VK, BN, Phyllox.)
February	Frost (winter) Wine evaluation	Wood preparation for Indexing Hot water treatment (FD, VK, BN, Phyllox.)
March	Pruning Wine evaluation	Grafting for Indexing Hot water treatment (FD, VK, BN, Phyllox.)
April	Budburst	Callousing for Indexing
May	Frost (late spring)	Nursery planting for Indexing
June	Shoot count Inflorescences count Growth Flowering	Yellow mosaic visual inspection Serological tests on leaves for Nepo-viruses
July	Coulure Leaf shape Laterals	Fanleaf visual inspection Serological tests on leaves for Nepo-viruses
August	Berry size Berry ripeness Bunch count Bunch shape	Leafroll visual inspection Crown-gall visual inspection Mycoplasms (FD, VK) visual inspection Bacterial necrosis (BN) visual inspection Indicator notation on: —Leafroll —Fanleaf —Fleck —Rugose wood complex
September	Drought damage Autumn tints Frost (autumn) Stem atrophy	Crown-gall visual inspection Mycoplasms (FD, VK) visual inspection Bacterial necrosis (BN) visual inspection Indicator notation on: —Leafroll —Fanleaf —Fleck —Rugose wood complex
October	Fallen Bunches Grape rot Grape yield Must density Total acidity pH-Value	Crown-gall visual inspection Mycoplasms (FD, VK) visual inspection Bacterial necrosis (BN) visual inspection Indicator notation on: —Leafroll —Fanleaf —Fleck —Rugose wood complex
November	Wood ripening Vinification	Crown-gall tests on wood Serological tests on wood for Nepo-viruses and Clostero-viruses
December	Wood research (counting, measuring, weighing)	Crown-gall tests on wood Serological tests on wood for Nepo-viruses and Clostero-viruses

FD = Flavescence dorée VK = Vergilbungskrankheit

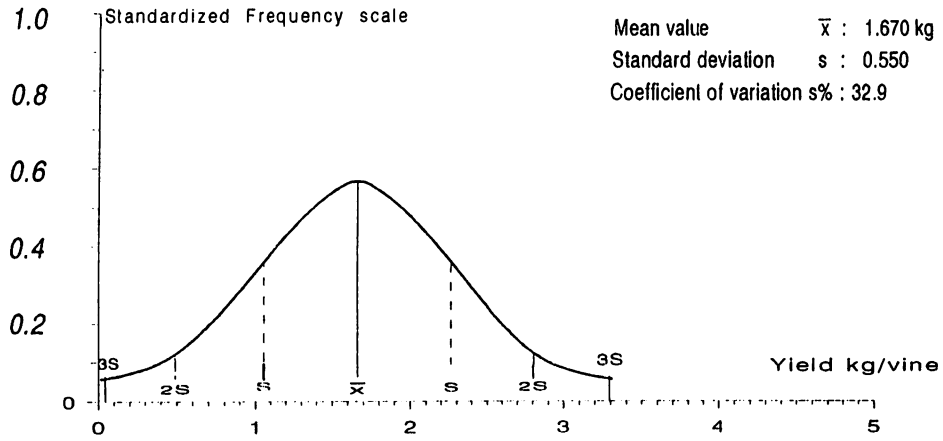

Figure 2. Normal distribution of individual vines (grape yield) of the Riesling clone 35 Trier in the trial year 1967 at Avelsbach (Mosel).

(Table 1). Crown-gall is caused by the bacteria *Agrobacterium vitis;* these tumorgenus bacteria can exist latently in propagation material and are potentially damaging to young grafted vines. Mycoplasms, transmissible by cicadas, are particular to 'Vergilbungskrankheit' (VK) and Flavescence doree; there can be latency in the propagation material. Recently there has been an increase in the potential incidence of this disease. Today viroids, as infecting agents in vines, are regarded less as a disease-causing agent and more as the cause of minor and possibly interesting differences between 'healthy' clones.

Further detrimental effects on the performance of vines can occur through hereditary changes. Mutations may occur in growing-tip meristems, and also through somatic mutations, which generally produce undesirable mutants.

Guidelines for Systematic Clone Selection

Concerning health it is logical to require that mother vines which are to be clones should be free from chronic disease (Schöffling and Goheen 1988) and genetic aberrations (hereditary deviations from variety type). Such vines still may lead to considerable difficulties. Disease causing agents can exist latently and hereditary deviations are recognizable only after many years of observation and exact performance measurements.

The first step is to obtain 'healthy' mother vines by means of diagnosis and/or heat therapy. Established procedures are available which are carried out in special laboratories and are partly described in the certification regulations.

With the 'healthy' mother vine and its infection-protected progeny, real clonal selection can be initiated. This relies on isolated external plantings, as the true performance capability of a clone and can only be assessed in this environment.

Concerning genetics, the breeding aims (in the first individual vine selection, pre-selection and main tests) are that the integrity and identity of varieties must be maintained. Following this selection individual vines and clones must be chosen, whose characteristics (Table 2) in relation to the normal distribution curve (Figure 2), are favorable for continuing the breeding aims. These are, in the above case, not those vines and clones which are to the left of the mean (X) but those which are to the right, i.e. vines and

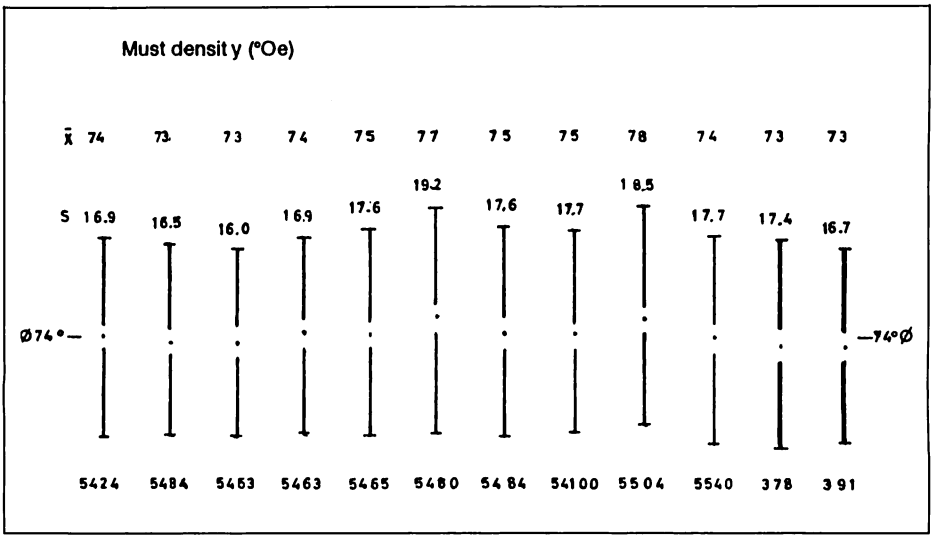

Figure 3. Must density levels with standard deviations (s) over 5 years of main tests with W. Riesling clones in the framework of the breeding aim of climatic tolerance, in the trial years 1973-1977.

clones whose function has not deteriorated through negative mutations.

With clone testing in the pre-selection, intermediate and principal tests, additional important dependencies can be evaluated and included in the selection criteria. Among these are quality and year parameters (Figure 3) as well as site parameters (8, 18 p. 267, 23, 24).

Performance Testing of Individual Vines and Clones

It is necessary to be aware of the significance of environmental influences when evaluating the performance of individual vines. Since the environment can differ, even in the smallest vineyards, replications are necessary to reduce experimental error. Four replications may be sufficient. The number of research years as well as the experimental design should also be considered (18). The first evaluations of the vines are for five years, especially in the initial individual vine selection where no replications are possible. The number of individual vines in the A-, B- and C-tests should be about 100.

For individual vines and clones various scales are used for evaluation which are linked to selection characteristics in certain periods of time (Table 2). The must density, total acidity and ph-value are determined with sample surveys of berries (22). The yield is determined from weighing the total clusters per replicate or from the numbers of bunches and their average weight (6).

Statistical evaluation of the results is simple in the initial individual vine selection. The four field method can be used (4). With this procedure four fields are set up through the mean of two required characteristics. For example, through the density of must (y) and the yield (x). The position of the clone in one of the four fields determines its qualification. In the preselection, intermediate and principal tests, more refined statistical methods can be used. For example, variance analysis, simple and pertial regressions.

Table 3. Data from selection work with Riesling clones in the trial years 1992 and 1993 at Avelsbach (Mosel).

Characteristics included	Clone Weinsberg 29	Clone Trier 34	Clone Trier 37	Clone Bernkastel 68	Clone Trautwein 356	Mean Value x	Dis-persion s	Max. Diff %
Blind buds	3,1	2,8	2,9	3,0	3,3	3,0	2,2	18
Live shoots	19,4	19,7	19,6	19,5	19,2	19,5	8,3	3
Bud burst (1-3, 1 = low)	2,1	2,1	2,0	2,1	2,0	2,1	0,2	5
Flowering (%)	16	17	17	16	13	16	8,2	31
Coulure (%)	37	35	35	37	36	36	12,1	6
Number of bunches	30,5	29,7	30,1	31,7	32,5	30,9	13,7	9
Weight of shoot-tips (g/vine)	151	222	236	167	153	186	156	56
Weight of foliage (g/vine)	356	502	484	392	404	427	192	41
Leaf size (square-cm)	171	173	172	172	168	171	14	3
Berry weight (g, ripening phase)	1,24	1,33	1,35	1,39	1,31	1,32	0,1	12
Must density (°Oe, ripening phase)	57	56	54	51	55	55	6,5	12
Total acidity (g/l, ripening phase)	19,3	20,2	20,8	21,4	20,3	20,4	1,6	11
pH-value (ripening phase)	2,79	2,76	2,76	2,75	2,76	2,76	0,1	1
Grape yield (kg/a) at harvest	70,0	61,7	68,6	68,9	72,6	68,4	29,7	18
Must density (°Oe) at harvest	81	79	77	77	79	79	5,2	5
Total acidity (g/l) at harvest	11,6	11,7	12,0	12,5	12,0	11,9	0,6	8
pH-Value at harvest	2,97	2,99	2,98	2,94	2,97	2,97	0,2	2
Fallen bunches (kg/a) at harvest	3,5	3,4	3,3	2,5	3,3	3,2	2,1	40
Grape rot (%) at harvest	21	21	21	18	19	20	4,2	17
One year wood (g/vine)	313	379	396	341	329	351	96	27

Costs of Clonal Selection

Stellmach (21) estimates the costs of clonal selection, up to the end of the principal test, to vary between $35,000 and $100,000 (50,000 and 150,000 DM). In the future the costs will increase because of higher taxes and costs of the sanitary selection and hot water treatment must be added. Further, an extended indexing of elite stocks and the installation of techniques for fast propagation of vines in individual businesses should contribute to the increase in costs.

Present State of Clonal Selection

There exist 45 clone-breeders, who deal with 53 white and 17 red grape varieties as well as with 10 rootstock varieties. They work with 578 clones, which were developed over four test phases and over three propagation stages. Building up a clone takes up to 20 years. The critical selection work (only 3% of the initial clones are chosen by the breeder) is divided into 70% private and 30% State breeders.

The breeding aims have the following priorities: stable performance, fungal 'resistance,' wine quality, must quality, reliability of yield, winter hardiness, growth behavior, loose-berried bunches, early grape ripening. The clonal propagation sites have a total area of about 400 ha. The sites should be sufficient to provide the German grape industry with 100% clonally selected plants. Full coverage is also to be achieved by having only virus and crown-gall tested plants at all propagation sites.

Certification by Law

The main procedure for systematic preservation of varieties and clones consists of a complex series of observa-

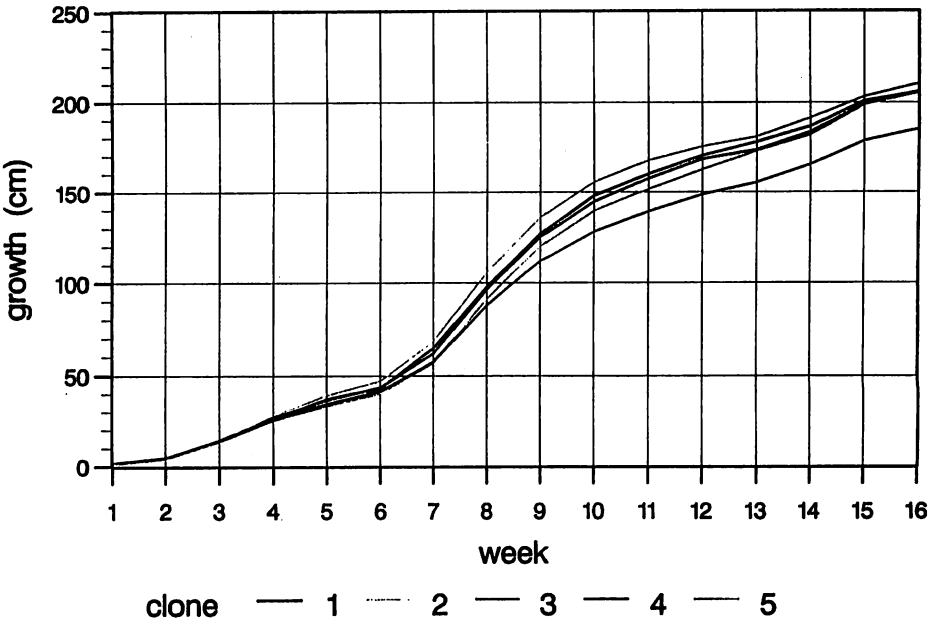

Figure 4. Growth-behaviour of 5 Riesling clones over 16 weeks from sprouting in the trial years 1979-1982 at Trier (Mosel).

tions and repeated tests (resulting in A-, B-, C-clones). Basic propagation material must come from C-clones. Certified plants must come from Basic plants. Besides being free from leaf-roll disease and ring spot diseases such as yellow mosaic, the new plant type requires tests on the mother stocks for nepo-viruses and for a complex of wood deformation (corky bark, Rupestris stem pitting and Kober stem grooving). Implementation of these requirements is controlled through the plant protection law with plant inspection orders, through European Union guidelines, realized in the seed material law and vine material orders, through the Federal Varieties Office in Hannover and the 'Certification' authorities, located in the regions. For example, for Rheinland-Palatinate it is at Bad Kreuznach.

Research Results in Clonal Selection

A high responsibility in this field is held by the Central Office for Clonal Selection in Trier (Mosel), which is an important national establishment. Its work extends over the fields of research as well as genetic and sanitary selection. It provides test results to clone-breeders, winegrowers, vine grafters and advisers through training courses and seminars, and also through lectures and publications. The Federal Institute for Breeding Research in cultivated plants encompassing the Institute for Grapevine Breeding Geilweilerhof in Siebeldingen (Pfalz) is another important research center. Research work includes methods of early diagnosis, biotechnical processes such as *in-vitro* culture of cells and tissue as well as methods of determining aroma in wine. These activities are in close co-operation with the Universities of Stuttgart-Hohenheim and Karisruhe.

Concerning the research results, along with sanitary quality, clone breeding has had an impacted on genetic selection. Together with the required breeding objectives, growth-

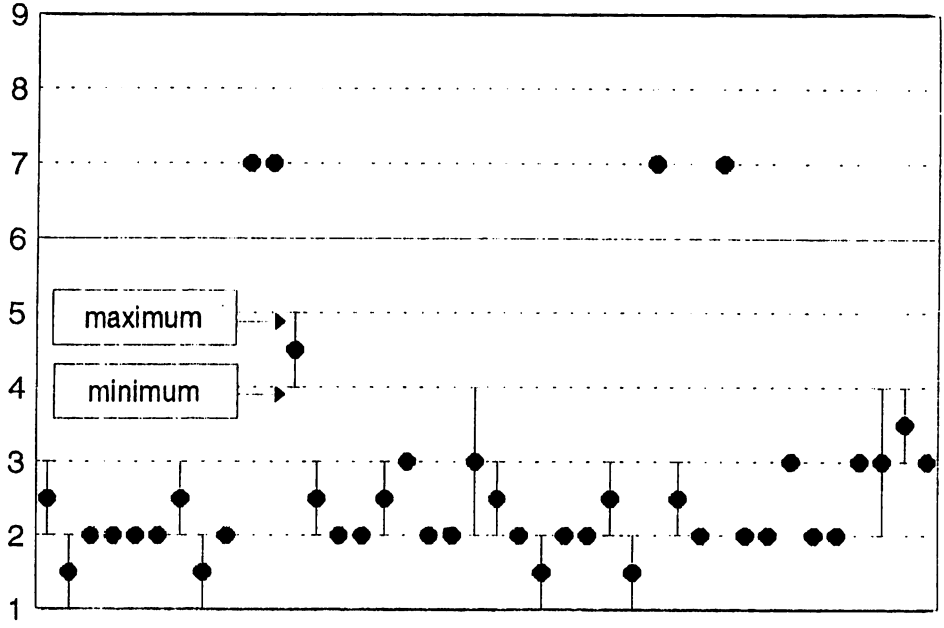

Figure 5. Resistance structure: cluster looseness with 40 A-clones of Pinot noir (1 = very compact cluster, 9 = very loose cluster) in the trial year 1995 at Avelsbach (Mosel).

structure, resistance-structure, quality-structure and yield-structure of clones determine the direction of research.

Growth Pattern

With regards to optimum growth structure we rely on clones which have less vigorous growth and satisfactory yield and quality. If less energy is needed for plant growth, less fertilizer will be required resulting in benefits to the environment and to production costs. A favorable starting position was to select A-clones with up to 20% less growth but with good yield levels.

Table 4. Harvest data of 4 Pinot noir clones with loose clusters compared with the average of 40 clones in the trial year 1995 at Avelsbach (Mosel).

Clone	Grape-yield kg/a	Density of must °Oe	Total-acidity g/l	Grape rot %
12	86	82	11.0	4
13	117	77	11.1	3
36	100	78	11.4	4
39	116	76	11.1	3
Average				
n = 40	119	74	10.1	11,0
n = 4	105	78	11.2	3,5
Difference	-12%	+6%	+11%	-32%

In Table 3 the clone Weinsberg 29 had the weakest growth but the second highest yield and the highest must density. This is therefore a clone that combines three advantages. Its weak growth in the weight of the one year old shoots is corroborated by the weight of the shoot-tips and the total foliage cuttings. However, in addition to the strength of growth we should also turn to the growth rhythm of the clones. This can also be the cause of color damage (13). On the other hand, it can interfere with the wood-ripening through a late conclusion of growth. Conversely when the termination of growth occurs too early the differen-

Table 5. Quality of musts and wines in relation to berry size of 9 White Riesling clones from 3 trial years and Avelsbach (Mosel).

Riesling clone	Grape yield kg/vine	Bunch weight g	Berry weight g	Must density °Oe	Total acidity g/l	Wine quality points (1-5, 5 = high)
Weis 21	2,467	80,4	1,05	88	10,0	2,67
Niederhausen 378	2,057	66,3	0,88	90	9,0	2,77
Trier 37	1,852	61,2	0,92	91	9,0	2,72
Heinz 65	2,165	72,0	0,99	91	9,2	2,84
Trier 34	1,786	60,8	0,83	92	8,7	2,85
Bernkastel 68	1,943	64,2	0,89	88	9,6	3,02
Neustadt 90	1,970	67,0	0,89	89	9,3	2,74
Trautwein 356	1,987	65,6	0,95	90	9,0	2,83
Weinsberg 29	1,870	62,2	0,80	92	8,8	2,98
Clone population	1,886	62,9	0,87	89	9,1	2,91
Mean value x	1,998	66,3	0,91	90	9,2	2,83
Maximum difference %	38	32	31	5	15	13

tiation phase of the bunches is shortened (10). So we established, with 5 Riesling clones, that one clone decreases its growth one week earlier (see Figure 4). This clone has a shorter differentiation phase, which has a negative effect on number of the clusters and on the development of the size of the grapes.

Resistance Behavior

Resistance characteristics in clones would include such things as bunch-rot infestation, amount of fallen bunches, sensitivity to frost, and susceptibility to chlorosis.

Bunch-rot resistance can be demonstrated by the example of A-clones of *Vitis vinifera* varieties Pinot noir,

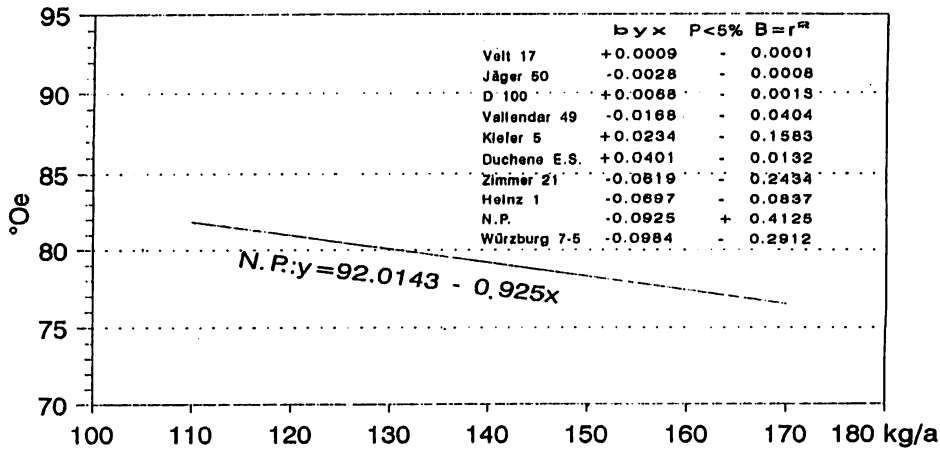

Figure 6. Must density in relation to grape yield of Müller Thurgau clones in comparison with the natural population (N.P.) in the trial years 1975-1977 at Nackenheim (Rheinhessen).

Table 6. Degree of dependence, B = r^2 with Significance level, of two Riesling clones in the trial year 1982 at Ockfen (Saar).

	Trier 37	Neustadt 90
Grape yield (g/vine) - Buds/vine (n)	0.2153***	0.2704***
Grape yield (g/vine) - Shoots/vine (n)	0.2777***	0.2927***
Grape yield (g/vine) - Growth (1 low-3)	0.0361*	0.1246***
Grape yield (g/vine) - Bunches/vine (n)	0.4970***	0.4516***
Grape yield (g/vine) - Bunch/weight (g)	0.0036⁻	0.0790***
Grape yield (g/vine) - Berries/bunch (n)	0.0292⁻	0.0906**
Grape yield (g/vine) - Grape rot (%)	0.0900**	0.0086⁻
Grape yield (g/vine) - Virus (1 low-5)	0.0708**	0.0004⁻

Gewürztraminer, Pinot gris, Pinot blanc and Auxerrois. Differences in bunch-rot resistance among clones were greatest in Pinot noir (336%) and in Auxerrois (200%).

Pursuing the selection aim 'loose berried bunches' will certainly help us to progress more quickly in the future. So with Pinot noir we found 4 clones, from a total of 40, which had loose berries (Figure 5). In Table 4 we see that the grape rot was about 32% lower. Coincidental with this the must-weight was 6% higher.

Concerning the portion of fallen bunches, in a trial with 11 A-clones of Riesling clone Bernkastel 68, the average differences between the years 1991-1993 amounted to 190%, ranging between 9 and 26 kg/acre.

Here we must try harder to find mutants which stand out as having a particularly stable stalk (trunk?) formation. As a basis for selection an earlier wood-ripening of the stalk (trunk?) should be considered. Consequently a possible decrease in the water circulation must be accepted.

In an example of **frost resistance** of 13 Riesling clones yield comparisons between a normal year (1978) and a frost year (1979) showed yield decreases of 25% to 56%. An investigation showed that late frost damage in 1991 on Pinot noir sub-clones caused a very different affect in the primary bud burst of side buds.

Results of investigations into **chlorosis-resistance** among clones would likewise suggest that a more intensive selection should be conducted. In 1980, when an estimate of chlorosis was taken, significant resistance differences of up to 30% were produced among the 13 Riesling clones tested.

Other resistances may also be worth investigating. Of particular importance would be resistance to **stem atrophy** especially in the list of susceptible *Vitis vinifera* cultivars like Riesling, Kerner and Trollinger, or resistance to **soil dryness** (2, 3).

Grape and Wine Quality

The quality of clones is interpreted as the maturity (ripeness) of must and wine Sekt. There also exists a relationship between quality and berry size. The results in Table 5 shows clones Weis 21 and Weinsberg 29 behave in such a way that when berries are smaller the must density and wine quality increase. According to French researchers (5), the aroma deposited in the berry-skin in small berries (relatively large surface) is more intensively accumulated than in large berries (relatively smaller surface).

The promotion of bud-burst and or flowering and promotion of maturity can be enhanced by early ripening of clones (e.g. the Piesporter Kettern Riesling mutant). Early ripening is beneficial since a later harvest, often

accompanied by bad weather conditions, can be avoided.

Harvest data provides incomplete information about clone quality, even when the clones show a favorable relationship between must-weight and grape yield (Figure 6). According to our findings it must certainly be deduced that the "goodness" of a clone's wine is not directly determinable (9, 25). More important is the wine sensory data. The wine sensory assessment data in Table 4 represents many tastings of test wines from clones growing under the same cultivation conditions. Greater differences, namely 42% in the nose, 42% in the taste, 38% in harmony and 39% in quality points demonstrate the significance of producing wines from clones (14, 15, 17). New research results also show that the wine ageing process (11) is not the same in clones (19). For example after 13 years of the wine of the Reisling clone 198 Gm lost more quality-potential than the wine of clones 64 Gm, 119 Gm and 239 Gm.

Grape Yield

Considerable differences in yield exist between clones of *Vitis vinifera* varieties cultivated under the same conditions, i.e., 18% according to Table 3, 38% according to Table 5. The size of the grape yield is determined primarily by the number of bunches. This can be proved by the coefficient of determination ($B = r^2$) for this relationship using two Riesling clones; Trier 37 and Neustadt 90 (Table 6). A second influence is the bunch weight, which is mostly affected by fruit set and, of course, the number of berries per bunch and the individual berry weight.

Future Perspectives for Clone Breeding

In Germany, clonal selection is based on plant performance and has been a 200 year-old tradition. Also the necessity for sanitary selection is well understood today but a series of problems have not yet been solved. Agents exist which are difficult to detect and may produce delayed effects several years after grafting, including a form of graft-incompatibility (7). It is not yet clear if these agents are infectious entities or genetic aberrations. Measures should be taken to improve the diagnostic capabilities and to avoid too much one-sideness in the genetic make-up of traditional grape-vine varieties.

The consequence of the ban on fumigation on virus-transmitting nematodes is that soil-borne diseases can spread unhindered. The productivity of sensitive varieties is quickly decreased and vineyards must be replanted earlier than normal. Leaving vineyard land fallow is economically a problem. The prospect of obtaining nematode-resistant rootstocks is a great hope. Molecular biology is also likely to provide new solutions.

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Autotetraploid 'Meiwa' Kumquat

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Abstract

The origin of the autotetraploid form of 'Meiwa' kumquat, *Fortunella crassifolia* Swing. is recorded. Some of the more prominent morphological changes in the phenotype that occurred as a result of autotetraploidy are described. Autotetraploid 'Meiwa' was developed for use as a tetraploid parent in crosses with diploid cultivars of *Citrus* to produce seedling triploid selections with superior traits. The morphological changes in the phenotype that occurred when the diploid Fortunella 'Meiwa' was converted to the tetraploid condition were analogous to the corresponding changes that occurred when diploid *Citrus* cultivars were converted to the tetraploid condition.

Introduction

Tetraploid forms of *Citrus* have been of interest to citrus breeders because of their potential usefulness as parents in producing triploid selections with superior traits from genetic combinations of diploids and tetraploids. Some cultivars of kumquat in the genus *Fortunella*, a close relative of *Citrus*, have a number of desirable traits that may be of value in citrus variety improvement. Tetraploid forms of *Fortunella* may also have a similar potential

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