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Variations in the galling reaction of grapevines: Evidence of different phylloxera biotypes and clonal reaction to phylloxera

by

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Unterschiedliche Vergallungsreaktion von Reben: Hinweise auf verschiedene Reblausbiotypen und klonspezifisches Verhalten gegen die Reblaus

Zusammenfassung: In standardisierten Gewächshausversuchen, die sowohl in Neuseeland als auch in Deutschland durchgeführt wurden, wurde der Vergallungsgrad von fünf Unterlagssorten (*Vitis*-Artkreuzungen) und einer *V.-vinifera*-Sorte bei Befall durch die Reblaus (*Dactylosphaera vitifolii* SHIMER) ermittelt. Neuseeländische Rebläuse induzierten an den Wurzeln der Unterlage 420 A und der Sorte Müller-Thurgau wohlentwickelte Nodositäten, während an den übrigen Unterlagen (SO 4, 3309 C, 1202 C, ARG 1) keine oder höchstens eine schwache Wurzelvergallung erfolgte. Blattgallen traten in Neuseeland nicht auf. Wurde dasselbe neuseeländische Rebenmaterial in Deutschland mit einer einheimischen Reblauspopulation infiziert, so zeigten alle Sorten außer 420 A und 1202 C eine ausgeprägte Vergallung der Blätter und Wurzeln. Diese Reaktionsunterschiede gegenüber den beiden Reblauspopulationen werden als Hinweis auf das Vorkommen verschiedener Biotypen der Reblaus in Neuseeland und Deutschland gewertet. Wenn dieselben Sorten, jedoch aus deutschen Rebsortimenten, mit deutschen Rebläusen infiziert wurden, vergallten die Blätter und Wurzeln aller Reben mit Ausnahme von ARG 1 und 420 A, so daß auch klonale Unterschiede zwischen den Unterlagssorten der beiden Länder vermutet werden müssen.

Key words: phylloxera, gall, Vitis, vine variety, clone, rootstock, resistance.

Introduction

Control of phylloxera has been achieved in most countries by grafting vines onto phylloxera resistant rootstocks derived from resistant American *Vitis* species, or hybrids of these and the susceptible European grape *V. vinifera*. As a result of intensive, long-term breeding and evaluation programmes in Europe, rootstocks have been selected for specific grape varieties and growing conditions.

The choice of rootstocks for use in grape growing areas outside Europe has been largely influenced by European evaluations of the levels of phylloxera resistance of individual rootstocks beginning with studies such as those of MILLARDET (1897) and RAVAZ (1897). BOUBALS (1966) carried out a detailed study of the resistance and susceptibility of rootstocks. He evaluated severity of tuberosities leading to 5 classes. Grapevines which were placed in classes 0 and 1 from the screening studies possessed practical resistance — i. e. tolerance — to phylloxera, while those in classes 2 and 3 had insufficient resistance to be used in the field. BOUBALS concluded that glasshouse techniques used for a rapid determination of resistance gave results which adequately reflected the observed levels of field resistance.

Hybrids of *V. vinifera* × *V. rupestris* have usually been considered susceptible to phylloxera. Included in this group are 1202 C and ARG 1. According to STELLWAAG (1928), 1202 C proved to be resistant in parts of Germany, while ARG 1 was susceptible in all areas. GALET (1956) reported a high number of tuberosities with 1202 C and also high susceptibility of ARG 1 from testing in France. BOUBALS (1966) placed both rootstocks on class 2. However, he noted that phylloxera were found rarely and were not growing in isolated 1202 C roots. These two stocks are now considered to have inadequate phylloxera resistance in Europe and are no longer used. DE KLERK (1974) and PONGRACZ (1983) report these rootstocks to be susceptible in South Africa. In contrast, LIDER *et al.* (1978) found that ARG 1 and 1202 C performed satisfactorily in phylloxera infested rootstock trials in California over 35—40 years. ARG 1 grafted vines planted in phylloxera infested vineyards in the Milawa area of Victoria, Australia in 1915 continued to show good vigour and fruit yields after nearly 70 years (KING, personal observations). KING *et al.* (1982) considered 1202 C and ARG 1 to be highly resistant to phylloxera in New Zealand.

As early as 1914, BÖRNER reported differences in the galling ability of phylloxera derived from southern France and from Lorraine, when inoculating the same grapevine material in eastern France. From this he postulated the existence of a 'southern' and a 'northern race' of phylloxera in Europe. More recently, biological variation in phylloxera infestation of grapevines has been reported from different parts of the world. SCHÄLLER (1959) in Germany and STEVENSON (1970) in Ontario found that 'strains' or 'biotypes' of phylloxera gallicoles differed in their ability to cause leaf galling of the same cultivar. DE KLERK (1974, 1976, 1979) noted that some rootstocks were attacked by the radicicole form of phylloxera in some areas of South Africa, but not in others. A similar situation has been noted in Australia by HELM (1983).

Establishment of biotype differences has been unsatisfactory to date. BÖRNER (at first 1924) tried to distinguish phylloxera races by the length of their stylets (see e. g. BÖRNER 1930; BÖRNER and HEINZE 1957). However, morphometric differences between populations have proved to be inconsistent (GÖTZ 1962 a and b; DE KLERK 1979), stylet length is influenced by environmental factors and therefore too unstable for taxonomic diagnosis (RILLING 1968) and correlations between stylet length and biological behaviour of phylloxera could not be affirmed (SCHILDER 1947; SCHÖLL 1955). Biochemical investigations by SCHÄLLER (1963) also showed no clear correlation between the amino acid composition of saliva and the phytopathological activity of phylloxera biotypes.

In New Zealand, Australia, Oregon and California, where most of the vineyard plantings are own-rooted *V. vinifera* vines, the damage potential of phylloxera is of continuing concern. Considerable effort is centred on the evaluation and selection of resistant rootstocks. Often however, the immediacy of the phylloxera problem (e. g. New Zealand vineyards) necessitates the adoption of recommendations from European evaluations. If different biotypes or races of phylloxera with differing virulence as first hypothesised by BÖRNER do exist, variation in rootstock resistance between and within grapegrowing areas has important implications to the selection of suitable rootstocks for a region. In an attempt to clarify the situation existing between New Zealand and Europe, an investigation of the levels of rootstock damage by both New Zealand and German phylloxera populations was carried out. The aims were:

1. to investigate galling reaction of the same rootstocks exposed to German or New Zealand phylloxera,
2. to establish if German and New Zealand strains of the same rootstock cultivars differed in their levels of resistance to galling by German phylloxera.

This paper presents the results of the first years trial work on the level of nodosity galling on 1-year-old roots. It also includes observations on leaf galling.

Materials and methods

Grapevine material used in the trials comprised one *V. vinifera* and five rootstock cultivars listed in Table 1. About 60 dormant two-bud cuttings of each of the cultivars were obtained from the Te Kauwhata Viticultural Research Station in September 1982. 30 cuttings of each cultivar were retained at the Ruakura Agricultural Research Centre and the remainder airfreighted to Germany and potted up at the Versuchsstation Langenscheiderhof near the BFAR Geilweilerhof.

Table 1

Trial cultivars, *Vitis* spp. breeding, class of phylloxera resistance/tolerance (based on tuberosities) according to BOUBALS (1966) and origin of New Zealand and German cultivars

Die untersuchten Rebsorten, ihre Abstammung, ihre Reblausresistenz bzw. -toleranz (aufgrund der Tuberositäten) nach der Klassifizierung von BOUBALS (1966) sowie die Herkunft der neuseeländischen und deutschen Sorten

Cultivar	*Vitis* breeding	Resistance class	Origin of material	
			New Zealand	Germany
420 A	*V. berlandieri* × *V. riparia*	0	France or Australia 1903	Geisenheim 1983
SO 4	*V. berlandieri* × *V. riparia*	1	Univ. of Calif. Davis 1967	Geilweilerhof
3309 C (3306 C) [1]	*V. riparia* × *V. rupestris*	1	France or Australia 1903	Geilweilerhof
1202 C	*V. vinifera* × *V. rupestris*	2	Univ. of Calif. Davis 1967	Geilweilerhof
ARG 1 (AXR I)	*V. vinifera* × *V. rupestris*	2	Univ. of Calif. Davis 1963	Geisenheim 1983
Müller-Thurgau	*V. vinifera*	3	Geisenheim 1962	Geilweilerhof

[1]) New Zealand cultivar probably 3306 C.

According to ampelographic descriptions, dried specimens and photographs sent to the INRA Station de Recherces Viticoles at Montpellier, all rootstock cultivars were considered to be correctly named (TRUEL, personal communication), with the exception of 3309 C which resembled 3306 C. However, as these two rootstocks have the same *Vitis* parentage and similar reported levels of phylloxera resistance, this likely misnaming does not significantly influence the trial results.

The same cultivars as above but of German origin (BFAR Geilweilerhof and FAG Geisenheim, Institut für Rebenzüchtung und Rebenveredlung; see Table 1) were tested at Langenscheiderhof only. Checking of the ampelographic characteristic confirmed that all cultivars were true to type.

Trial methods were standardised as much as possible in the two countries.

New Zealand trial

30 cuttings of each cultivar were forced in a pumice sand medium in September 1982. In November, the plants were potted into 1 l plastic pots filled with a medium composed of 36 % clay, 54 % peat, and 10 % coarse sand. No fertiliser was included in the potting medium. 20 replicates of each cultivar to be infested with phylloxera were confined to one glasshouse and 10 replicates were kept in an adjacent insect proof glasshouse to be used as uninfested control vines. Temperature and light conditions in the two glasshouses were identical. Water was supplied according to vine requirements. Temperature fluctuated between 15 and 25 °C over the trial period.

A complete fertiliser (N : P : K analysis — 15 : 11 : 15) was applied at monthly intervals commencing in November. 5 applications of 125 ml of 0.2 % solution/vine were given up to the end of active vine growth.

Phylloxera populations were introduced to the infested treatments in December 1982 and again in January 1983. The phylloxera were collected on roots taken from an infested block of Baco 22 A grapevines at Te Kauwhata Viticultural Research Station. A 3—5 cm length of grape root about 5—7 mm in thickness which had large numbers of adult radicicoles, larvae and eggs was placed against the vine roots in each pot.

In mid-April 1983 an assessment was made of the level of phylloxera galling on the root systems of all vines. A standard 93.5 cm^2 area of the visible peripheral root system was examined under a binocular microscope using a template to delineate the area, and the numbers of live nodosities in the area were counted. All phylloxera-induced root swellings were classified as galls if insects were feeding on the roots. Leaves of all vines were examined at regular intervals during the growing season for the presence of galls.

When vines were fully dormant in July 1983, top growth was cut back to 3 buds and weighed.

German trials

Grapevines were kept in a glasshouse at temperatures between 15 and 25 °C with occasional rises towards 30 °C during summer. From October 1982 to May 1983, a day-length of 16 h was maintained by additional illumination with fluorescent tubes. All cultural practices (pots, soil mixture, fertilising and watering) were similar to those of the New Zealand trial.

In trial 1, the New Zealand derived cuttings were rooted in September 1982 and planted into pots in November. In the middle of December and again 2 weeks later, 12 plants of similar vigour of each cultivar were inoculated with a German phylloxera population. These phylloxera had been reared over more than 3 decades at Langenscheiderhof on different American *Vitis* species and hybrids in both glasshouses and in the field. All phylloxera used in the present trial were taken from greenhouse host vines. Leaf pieces with a total of 30—40 egg-filled galls were introduced into the pots and pieces with 15—20 leaf galls fastened to the shoot tips.

In trial 2, the cultivars of German origin were propagated in March 1983. In May/June, 12 replicates of each treatment were infested with the German phylloxera on roots and leaves using leaf galls as before.

In trial 3, further vines of the German origin cultivars were inoculated in July/August on the roots only. 12 pots of each cultivar were infested by phylloxera on leaf galls and about 30 root galls (nodosities) with large numbers of eggs were introduced into each of a further 6 pots/cultivar. The radicicole form used had established on host roots over a number of generations from spring 1983.

The level of phylloxera galling was assessed at the times given in Tables 3—5. Representative samples of 2 leaves and root portions comprising at least 100 root tips (including nodosities) were taken from each plant for evaluating mean gall frequency, expressed as numbers of nodosities/100 root tips and number of leaf galls/100 cm^2 of leaf area, respectively, as well as of mean gall size according to the 9-class score below:

On leaves:
1 = Local lesions only
3 = Imperfect, frequently sterile galls
5 = Fertile galls, up to 3 mm in diam.
7 = Fertile galls, about 4 mm in diam.
9 = Fertile galls, from 5 mm in diam.

On roots:
1 = Local lesions, no swelling
3 = Nodosities, up to 1 mm in diam.
5 = Nodosities, up to 2 mm in diam.
7 = Nodosities, up to 3 mm in diam. up to 10 mm in length
9 = Nodosities, from 3 mm in diam. from 10 mm in length

Table 2

Galling of roots in April 1983 of *Vitis* cultivars derived from New Zealand and infested with New Zealand root form phylloxera

Die Wurzelreaktion von Rebsorten neuseeländischer Herkunft bei Befall durch neuseeländische Wurzelrebläuse (April 1983)

Cultivar	Mean no. nodosities/vine[1]) ± SE	Range
420 A	54.2 ± 25.2	21—108
SO 4	0	—
3309 C (3306 C)	0	—
1202 C	0.8 ± 2.0	0—8
ARG 1	0.5 ± 1.0	0—3
Müller-Thurgau	51.3 ± 19.5	26—107

[1]) On 93.5 cm^2/vine.

Results

New Zealand trial

No phylloxera galling occurred on leaves of any cultivar during the trial. Although leaf galls have occasionally been noted in the field in New Zealand on Baco 22 A and ARG 1 vines, leaf galling is very rare and its absence from the trial vines was expected.

The level of phylloxera root galling in April is shown in Table 2. No nodosities developed on 3309 C and SO 4. ARG 1 and 1202 C rootstocks also demonstrated a high level of resistance to nodosity formation with few phylloxera on the roots at the time of the assessment.

Large numbers of phylloxera and numerous nodosities occurred on the roots of 420 A and Müller-Thurgau. At the time of the second introduction of phylloxera in January 1983, a high level of galling was evident on 420 A roots, suggesting that this rootstock was infested by phylloxera as readily as was the *V. vinifera* cultivar.

Table 3

Trial 1: Galling of leaves and roots in March 1983 of *Vitis* cultivars derived from New Zealand and infested with German phylloxera in leaf galls

Versuch 1: Die Blatt- und Wurzelreaktion von Rebsorten neuseeländischer Herkunft bei Befall durch deutsche Rebläuse aus Blattgallen (März 1983)

Cultivar	Mean gall size [1])	
	Leaves	Roots
420 A	1.0	1.0
SO 4	3.1	4.2
3309 C (3306 C)	5.5	4.1
1202 C	1.0	1.0
ARG 1	5.2	4.5
Müller-Thurgau	3.7	4.1

[1]) For classes of gall size see 'Materials and methods'.

Analysis of the vine shoot weights in July 1983 showed that there were no significant differences between the phylloxera infested and uninfested plants of the same cultivar. The high level of damage to the root systems of 420 A and Müller-Thurgau did not influence vine growth in this trial, either because the vines had been infested for a relatively short period, or nodosity damage to the young, fine feeding roots is not as important as tuberosity damage to the older, thicker root system.

German trials

The root and leaf galling of the New Zealand derived *Vitis* cultivars infested with German phylloxera in leaf galls in trial 1 is shown in Table 3. Within the same cul-

Table 4

Trial 2: Galling of leaves and roots in June/July 1983 of *Vitis* cultivars derived from Germany and infested with German phylloxera in leaf galls

Versuch 2: Die Blatt- und Wurzelreaktion von Rebsorten deutscher Herkunft bei Befall durch deutsche Rebläuse aus Blattgallen (Juni/Juli 1983)

Cultivar	Leaves		Roots	
	Mean no. galls/ 100 cm^2 of leaf area	Mean gall size[1])	Mean no. galls/ 100 root tips	Mean gall size[1])
420 A	— [2])	1.0	—	1.0
SO 4	43.9	4.8	42.6	5.1
3309 C	29.2	6.1	41.2	4.3
1202 C	56.7	6.6	23.7	4.1
ARG 1	—	1.0	—	1.0
Müller-Thurgau	45.4	4.6	12.1	4.8

[1]) For classes of gall size see 'Materials and methods'.
[2]) Not evaluated.

Table 5

Trial 3: Galling of roots in July/August 1983 of *Vitis* cultivars derived from Germany and infested with either leaf gall or root gall forms of German phylloxera

Versuch 3: Die Wurzelreaktion von Rebsorten deutscher Herkunft bei Befall durch deutsche Reblläuse von Blatt- oder Wurzelgallen (Juli/August 1983)

Cultivars	Infested by leaf galls		Infested by root galls	
	Mean no. galls/ 100 root tips	Mean gall size[1])	Mean no. galls/ 100 root tips	Mean gall size[1])
420 A	—[2])	1.0	—	1.0
SO 4	33.8	5.0	11.8	4.5
3309 C	43.0	4.2	10.2	4.0
1202 C	41.6	4.5	27.7	4.3
ARG 1	—	1.0	2.5	3.0
Müller-Thurgau	18.2	3.7	5.0	4.0

[1]) For classes of gall size see 'Materials and methods'.
[2]) Not evaluated.

tivars, roots and leaves showed similar tendencies as to gall size. All varieties were readily galled with the exception of 420 A and 1202 C. The result with 420 A is in accordance with classification 0 by BOUBALS (1966) which excludes nodosities. On the other hand, GALET (1956) noted numerous nodosities with a few slight tuberosities on this rootstock. The failure of phylloxera to cause galling of 1202 C is most surprising. This is particularly so, as ARG 1, which has a reported similar level of phylloxera resistance to that of 1202 C (GALET 1956; BOUBALS 1966), formed galls in this trial. Leaf galling of Müller-Thurgau and other *V. vinifera* cultivars is commonly observed in the Langenscheiderhof glasshouses and probably due to the warm and humid atmosphere.

The response of roots and leaves of the German derived cultivars to German phylloxera in leaf galls in t r i a l 2 is shown in Table 4. 3309 C, SO 4 and Müller-Thurgau were galled in both trials by German phylloxera, regardless of the source of the plant material, and 420 A was again very resistant to galling. However, German derived ARG 1 was resistant and 1202 C was galled. These results are the reverse of those on New Zealand derived material (Table 3).

The level of root galling of German derived vines infested with either a leaf gall or root gall form of German phylloxera in t r i a l 3 is shown in Table 5. The levels of root galling following introduction of leaf galls in July/August closely matched those from the May/June inoculation (Table 4) and those for root gall introduction. These results demonstrate that the timing or form of phylloxera introduced into the trial did not markedly affect the galling reaction. Although there was a tendency for fewer nodosities where vines were infested with phylloxera on root galls (Table 5), this is most likely to be due to the short period of less than one month that the plants were infested with the insect. Some galling was found on ARG 1 vines infested with phylloxera from root galls, but only 2.5 % of the root tips examined had nodosities, generally of a small size. 1202 C was readily galled by both forms of phylloxera and again the young roots of 420 A were highly resistant.

Discussion

Evaluations of rootstock resistance (in the sense of tolerance) have generally stressed the necessity of using the measure of tuberosity damage to 1 year and older woody roots as the critical index of phylloxera resistance. Galling in the form of nodosities on the young roots is considered unimportant as a measure of the ability of a rootstock to resist phylloxera damage. This point is acknowledged and evaluations of tuberosity damage are being continued in the second year of this trial. However, the results in Table 2 and 3 summarised in Table 6 demonstrate some major differences in the reaction of the New Zealand *Vitis* material to the two different sources of phylloxera.

Table 6

Galling response of *Vitis* cultivars derived from New Zealand and Germany exposed to New Zealand and German phylloxera populations

Die Vergallungsreaktion von Rebsorten neuseeländischer und deutscher Herkunft bei Befall durch neuseeländische und deutsche Reblauspopulationen

Cultivars	New Zealand grapevines infested by			German grapevines infested by	
	N.Z. phylloxera	German phylloxera		German phylloxera	
	Roots	Roots	Leaves	Roots	Leaves
420 A	+	–	–	–	–
SO 4	–	+	+	+	+
3309 C [1])	–	+	+	+	+
1202 C	– (+)	–	–	+	+
ARG 1	– (+)	+	+	–	–
Müller-Thurgau	+	+	+	+	+

[1]) New Zealand cultivar probably 3306 C.
\+ = General galling.
– (+) = Occasional galling.
– = No galling.

When infested with New Zealand phylloxera none of the cultivars showed leaf galling whereas most of the New Zealand material formed leaf galls when infested with the German population. The total absence of leaf galls in the New Zealand trial is possibly a result of using the radicicole phylloxera form, which were unable to initiate the leaf cycle although under both experimental or natural conditions root form crawlers may sometimes induce galls on leaves (RILLING 1964). Leaf galling of Müller-Thurgau or other *V. vinifera* cultivars is generally not observed in the field in Germany, but galling of the leaves of rootstocks and hybrid cultivars is common. In contrast, leaf galling rarely occurs in New Zealand. The absence of leaf galling in the New Zealand trial indicates inherent differences between the New Zealand and German phylloxera populations.

Comparing the results obtained on roots of the New Zealand derived material in the both countries, only Müller-Thurgau with many well developed nodosities and 1202 C with few or no root galls performed similarly in New Zealand and Germany. The other four cultivars showed opposite reactions towards the phylloxera populations of

the two study sites. Such variation is strong evidence that the New Zealand and German phylloxera show a different behaviour on certain grapevines as indicated by the level of nodosity formation.

The results of infesting vines with either root gall or leaf gall forms of phylloxera (Table 5) showed no differences in the galling reaction of the cultivars. Thus, the introduction of different forms of phylloxera in the New Zealand and German trials (radicicole and gallicole forms, respectively) cannot be advanced as an argument to explain the major differences within cultivars. As leaf-born crawlers move to the roots and give rise to new root form generations during the complete natural life cycle, differences due to the use of phylloxera forms were not expected.

Comparison of Tables 3 and 4 strongly suggests the existence of different strains of rootstocks which may arise from clonal differences. The New Zealand strain of ARG 1 was readily galled by German phylloxera and yet the roots of German ARG 1 rootstock were found to be very resistant to the same phylloxera source. This result was totally unexpected in view of the high susceptibility of ARG 1 in European evaluations of phylloxera resistance. The converse situation with 1202 C is also difficult to explain without acknowledging the possible existence of different strains of rootstocks. Unfortunately records do not permit the exact source and clonal identity of the New Zealand cultivar material to be established further than shown in Table 1. However, it is likely that clonal variation exists between the New Zealand and German cultivars leading to variation in the phylloxera galling reaction.

Conclusions

New Zealand and German phylloxera populations clearly differed in the ability to gall the New Zealand origin cultivars in these trials. The hypothesis is advanced that strain or biotype differences exist between the two populations. The origin of phylloxera in New Zealand is unknown but possibly the populations have evolved in the two countries to the extent that they now differ in some critical aspects of their physiology. In addition, there is strong evidence for the existence of clonal variations within rootstock cultivars.

The results provide an explanation for the established usefulness of the ARG 1 and 1202 C rootstocks in phylloxera infested areas of California, Australia and New Zealand in spite of their being considered to have unsatisfactory levels of phylloxera resistance in Europe and South Africa.

Variations in the galling reaction of rootstocks due to phylloxera biotype and clonal cultivar variation stresses the necessity for local evaluation of rootstocks for resistance to local populations of phylloxera. The existence of phylloxera biotypes and rootstock clones ranging in their phylloxera resistance has important implications for rootstock breeding programmes as well as in the selection of clonal material and its importation into other grapegrowing countries. Further, the accidental introduction of a new biotype of phylloxera into an established area of vines grafted on resistant rootstocks could initiate an apparent breakdown of the resistance.

Summary

The level of galling of five rootstocks (*Vitis* spp. hybrids) and a *V. vinifera* variety by phylloxera (*Dactylosphaera vitifolii* SHIMER) was assessed in standardised glass-

house trials in New Zealand and Germany. The roots of 420 A rootstock and the *V. vinifera* variety Müller-Thurgau were readily galled by New Zealand phylloxera but little or no galling occurred on the other rootstocks (SO 4, 3309 C, 1202 C, ARG 1). No leaf galling reaction occurred. When the same New Zealand grapevine material was infested with a German population of phylloxera in Germany, the roots and leaves of all cultivars except 420 A and 1202 C were readily galled. This variation in the plant galling reaction by the two phylloxera populations is considered as evidence of the existence of different phylloxera biotypes between New Zealand and Germany. Furthermore, when the same cultivars, but of German origin, were infested with German phylloxera, the leaves and roots of all except ARG 1 and 420 A were readily galled suggesting clonal differences in rootstocks between the two countries.

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References

BÖRNER, C.; 1914: Über reblaus-anfällige und -immune Reben. Biologische Eigenheiten der Lothringer Reblaus. Biol. Centralbl. **34**, 1—8.

— —; 1930: Reblaus. In: MÜLLER, K. (Hrsg.): Weinbaulexikon, 648—665. Verlagsbuchhandlung Paul Parey, Berlin.

— —; HEINZE, K.; 1957: Aphidina — Aphidoidea. In: BLUNCK, H. (Hrsg.): Handbuch der Pflanzenkrankheiten (begründet von P. SORAUER), Bd. **V**, 4. Lief., 1—402. Paul Parey, Berlin, Hamburg.

BOUBALS, D.; 1966: Etude de la distribution et des causes de la résistance au phylloxéra radicicole chez les vitacées.Ann. Amélior. Plants 16, 145—184.

DE KLERK, C. A.; 1974: The grapevine phylloxera. No. F1. Diseases and Pests. Oenological and Viticultural Series. Department of Agricultural Technical Services, Pretoria, South Africa.

— —; 1976: Preliminary results on determining the phylloxera resistance of rootstocks in the Stellenbosch and Olifants River areas [Afrik.]. Wynboer (540), 65—67.

— —; 1979: An investigation of two morphometric methods to test for the possible occurrence of morphologically different races of *Daktulosphaira vitifoliae* (FITCH) in South Africa. Phytophylactica **11**, 51—52.

GALET, P.; 1956: Cépages et Vignobles de France. Vol. **I**: Les Vignes Américaines. Imprimerie Paul Dehan, Montpellier.

GÖTZ, B.; 1962 a: Reblausrassen und Unterlagenproblem. Rebe und Wein **15**, 4—6.

— —; 1962 b: Morphologische Rasseuntersuchungen an Wurzelreblausen aus Baden-Württemberg. Wein-Wiss. **17**, 267—276.

HELM, K. F.; 1983: Phylloxera in Australia. Austral. Grapegrower Winemaker (239), 16—20.

KING, P. D.; MEEKINGS, J. S.; SMITH, S. M.; 1982: Studies of the resistance of grapes (*Vitis* spp.) to phylloxera *(Daktulosphaira vitifoliae).* N.Z. J. Exp. Agricult. **10**. 337—344.

LIDER, L. A.; FERRARI, N. L.; BOWERS, K. W.; 1978: A study of longevity of graft combinations in California vineyards with special interest in the *vinifera* × *rupestris* hybrids. Amer. J. Enol. Viticult. **29**, 18—24.

MILLARDET, A.; 1897: Américains ou franco-américains. Rev. Viticult. **8**, 606—612.

PONGRÁCZ, D. P.; 1983: Rootstocks for Grapevines. David Philip Publisher, Cape Town, Johannesburg, London.

RAVAZ, L.; 1897: Contribution a l'étude de la résistance phylloxérique. Rev. Viticult. **7**, 109—114.

RILLING, G.; 1964: Die Entwicklungspotenzen von Radicicolen- und Gallicoleneiern der Reblaus (*Dactylosphaera vitifolii* SHIMER) in Beziehung zu Umweltfaktoren. Vitis **4**, 144—151.

— — ; 1968: Versuche zur Modifikabilität der Stechborstenlänge bei der Reblaus (*Dactylosphaera vitifolii* SHIMER). Vitis **7**, 130—140.

SCHÄLLER, G.; 1959: Untersuchungen über die Gallbildung und Nekrosereaktion der Rebensorten unter Berücksichtigung der Rassendifferenzierung der Reblaus. Phytophaol. Z. **36**, 67—83.

— — ; 1963: Biochemische Rassentrennung bei der Reblaus (*Viteus vitifolii* SHIMER) durch Speichelanalysen. Zool. Jb. Physiol. **70**, 278—283.

SCHILDER, F.; 1947: Zur Biologie der Reblausrassen. Züchter **17/18**, 413—415.

SCHÖLL, S.; 1955: Morphologische Rasseuntersuchungen an Reblausfundatrixketten aus südbadischen Amerikanerschnittgärten. Z. Pflanzenkrankh. **62**, 711—721.

STELLWAAG, F.; 1928: Die Weinbauinsekten der Kulturländer. Verlagsbuchhandlung Paul Parey, Berlin.

STEVENSON, A. B.; 1970: Strains of the grape phylloxera in Ontario with different effects on the foliage of certain grape cultivars. J. Econ Entomol. **63**, 135—138.

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