ACTA SCIENTIARUM POLONORUM

Acta Sci. Pol. Hortorum Cultus, 16(3) 2017, 141–149

www.acta.media.pl ISSN 1644-0692 DOI: 10.24326/asphc.2017.3.14

ORIGINAL PAPER

Accepted: 13.02.2017

ROOTING OF ROOTSTOCK 'BÖRNER' AND ITS COMPATIBILITY WITH VARIOUS WINE- AND TABLE-GRAPE VARIETIES

Stanko Vršič

University Centre of Viticulture and Enology Meranovo, Faculty of Agriculture and Life Sciences, University of Maribor, Slovenia

ABSTRACT

The rooting and compatibility of 'Börner' rootstock with various wine- ('Furmint', 'Regent', 'Riesling', 'Sauvignon Blanc', and 'Welschriesling') and table-grape ('Muscat Bleu', 'Ester', and 'Nero') varieties were evaluated over two growing seasons. The 'Börner' rootstock was compared to the most prevalent rootstocks ('5BB' and 'SO4') in Slovenia. The trial based on a randomised complete block design with four replications (50 grafted plants per replicate). As an index of compatibility, the callus development and the percentage of first grade grafted vines were determined, as well as dry weight of roots in wine varieties in 2006. After the callusing process (heat forcing), the differences in callus development were greater between the years than among rootstocks, which were the most obvious with the wine-grape variety 'Furmint' as a scion. In 2005 there were 38% more grafts with a partial developed callus comparing to 2006, while in this particular year, for most varieties, the average percentage of the first grade grafted vines and the roots dry weight were higher when the '5BB' rootstock was used. Lower grafting success of 'Börner' rootstock is more a result of less developed roots (loamy soils) as compatibility with various varieties.

Key words: grafted vine, rootstock, compatibility, 'Börner'

INTRODUCTION

In a worldwide context, grape phylloxera (*Daktulosphaira vitifoliae* Fitch) is managed predominantly by the use of resistant rootstocks developed through conventional breeding of hybrid crosses of American *Vitis* species with root resistance (predominantly *V. riparia* Michx) [Granett et al. 2001, Benheim et al. 2012]. The parasite was introduced from America to Europe in the middle of the nineteenth century. Use of insecticides is limited in effect [Granet and Kocsis 2000, Kocsis et al. 2002]. Large populations of this pest have negative effects on rootstock productivity. The Phylloxera develops more aggressive biotypes which overcome the resistance of some rootstocks [Granet et al. 2005], and damage due to phylloxera increases [Martinez-Peniche 1999].

In commercial viticulture the scions of high quality wine-producing varieties (*V. vinifera* L. *subsp. vinifera*) are mostly grafted on *V. berlandieri* × *V. riparia* hybrids, which make up the acknowledged rootstock cultivars currently in use. However, the most of available rootstocks are only partially resistant and they isolate the place of phylloxera attack by cork layers from the inner tissue of the roots, thereby reducing further damage. Thus, the tolerance of new rootstocks against this pest has to be tested [Rühl et al. 1999]. At the end of the nineties in Germany the 'Börner' rootstock was selected from the

✉ stanko.vrsic@um.si

hybrid progeny derived from crossing *V. riparia* 183 Gm × *V. cinerea* Arnold [Korosi 2011]. 'Börner' exhibits a typical hypersensitive response to phylloxera attack with local necrosis [El-Nady 2001] leading to necrosis around the puncture sites and high level or absolute resistance on roots [Zhang et al. 2009]. Therefore this rootstock is a highly attractive genetic resource for further rootstock breeding. Its considered to have the most potential and to be the most important donor of resistance against phylloxera [Blank et al. 2009], but it is less tolerant to the heavy soils and lime-induced chlorosis [Pavloušek and Michlovský 2007, Pavloušek 2009]. When breeding and selecting rootstocks for certain site conditions not only the resistance to phylloxera, but also their affinity and compatibility, growth intensity [Pavloušek 2010], vigour [Pellegrino et al. 2005, Schmid and Manty 2009], adaptation to soil [Tarricone et al. 2011], and climatic conditions are of great importance [Patil et al. 2005, Pire et al. 2007, Pavloušek 2011, Vršič et al. 2014].

In young grafted grapevines, the scion has a major effect on the biomass accumulation in the shoot, as well as the root system. Also the rootstock has a significant effect on root development. This aspect of rootstock/scion interactions should be taken into account when selecting rootstocks [Tandonet et al. 2009, Cookson et al. 2012]. In grafted vines, the root development and healing of the graft union were particularly affected by the water content and carbohydrate reserves stored in the previous year in the canes used for scions and rootstocks [Vršič et al. 2009]. The mechanism of graft incompatibility is not yet fully understood. Many reports focus on this problem in order to understand the mechanisms of graft development [Pina and Erra 2005], and results showed an incompatibility exists between different root -stock/scion combinations [Gökbayrak et al. 2007]. The X-ray tomography technique used to evaluate graft quality showed that the good grafts had tissues well connected in the wood and phloem, and had a regular structure [Milien et al. 2012].

The main objective of this study was to investigate the compatibility of various wine- and table--grape varieties with 'Börner' rootstock compared to the most prevalent rootstocks ('5BB' and 'SO4') in Slovenia.

MATERIAL AND METHODS

In 2005 and 2006 the wine grape varieties 'Welschriesling', 'Furmint', 'Riesling', 'Sauvignon Blanc', and 'Regent' and the table grape varieties 'Muscat Bleu', 'Ester', and 'Nero' were grafted onto 'Börner' (*Vitis riparia* 183 Gm × *V. cinera* Arnold) rootstock and were compared with '5BB', 'SO4' (*V. berlandieri* Planc. × *V. riparia* Michx.). The canes of scions and rootstocks were collected (last week of January) in the germplasm repository vineyard at the University Centre of Viticulture and Enology Meranovo, Faculty of Agriculture and Life Sciences, in Slovenia. Prior to grafting, the dormant cuttings of rootstocks (35 cm length) and scions were disinfected by Chinosol W (0.5%) and kept in plastic bags at 2°C until the grafting. In total, 200 grafts of each rootstock/scion combination were bench grafted (last week of March) with "Omega-star" grafting machine. Grafts were callused in plastic boxes with moist sawdust for three weeks at a temperature of 26–28°C, and with humidity of about 80–90%. The grafts of all grafted rootstock/scion combinations were waxed (15 cm from the top) before callusing, and before planting in the field nursery. Before the planting the graft units were left in water for 24 h and then planted into the row ridges covered with a black colour plastic foil (0.5 mm thickness). The trial based on a randomised, complete block design with four replications, included 50 grafts per replicate. The trials were conducted in a commercial nursery near Ptuj (46°46'N, 15°81'E, 280 m a.s.l,) in North-East Slovenia. The soil was medium deep and loamy, with a pH of 6.11 (0.1 mol/L KCl). Based on the ammonium lactate extraction procedure, the soil contained 152 mg P, 289 mg K, and 135 mg Mg per kg of air-dried soil

from a soil layer of 0–30 cm. The soil samples were taken before the start of the trials. The data of weather conditions and the recommended harvest date of the latest ripening variety 'Furmint', from all those involved in the experiment, are presented in Table 1.

The compatibility of various rootstock/scion combinations was analysed by the degree of callus development on the graft union after callusing, and the percentage of first grade grafted vines (Council Directive 68/193/EEC: 1968 and Official Gazette of RS, No. 93/05) and the dry weight of roots after one season in the nursery. To evaluate the success of grafting, the level of callus development around the graft union was determined. After the forcing period, the grafted vines were divided into three groups: (1) vines with a completely developed callus; (2) vines with a partially (incomplete) developed callus; and (3) vines without a callus. After a season of growth in the nursery field, the grafted plants were undercut and ripped out from the soil. At that point the healing of the graft union, and extent of the root system was evaluated. The percentage of the first grade grafted plants were characterised by at least three equally developed roots that were thicker than 3 mm (the accepted minimum; Official Gazette of RS, No. 93/05). In 2006 the first grade grafted vines were divided into two groups: those with three roots, and those with four or more roots. At the end of the growing season the roots were dried at 105°C to determine their dry weight. In 2005 after a season of growth in the nursery field, the grafts have been planted in the trial in vineyard.

The differences between rootstocks for each variety were verified using a one-way analysis of variance (ANOVA). The statistical evaluation of data was performed with the SPSS 19.0 programme ($P \leq 0.05$). Means were compared using the Tukey's HSD test.

RESULTS AND DISCUSSION

Callus development

The 'Börner' rootstock had similar compatibility in 2006 with the wine and table grape varieties as 'SO4' and '5BB' rootstocks, except with the 'Sauvignon' and 'Muscat bleu', where the percentage of grafts with the complete developed callus was higher than in '5BB', and in 'Regent' where it was lower than in both standard rootstocks (fig. 1). In 2005 in these three varieties were no significant differences in callus development. The differences in callus development at the graft union were greater between the years than among rootstocks ($P \leq 0.05$). In 2006, the percentage of grafted vines with a completely developed callus in all across combinations was 83.4%, which was 23.6% higher (20% with '5BB', 22% 'SO4', and 29% with 'Börner') than in 2005 (59.8%). This reduced development of callus at the graft union in 2005 could have been due to poor cane maturity and lower accumulation of reserve substances [Vršič et al. 2009] in canes in the previous year (e.g. in 2004), as a result of very late harvest date in this year, especially for the 'Furmint'. The harvest date for 'Furmint' in 2004 was 25 days later than the average for the whole decade 2000–2009 and two weeks later than in 2005 (tab. 1). The healing of the graft union and root development is affected by water content and stored reserves (mainly carbohydrates) in the canes of scions and rootstocks [Vršič et al. 2009]. Healing of graft union is a complex biochemical and structural process from the surface cut until the functional vascular system establishment [Pina and Errea 2005].

The greatest difference in callus development between the years was determined for 'Furmint' (on average 40%; in 'Börner' rootstock 47%). The lowest differences between the years (10%) were in 'Regent' on 'Börner' and 'Sauvignon Blanc' on 'SO4'. In 2005 'Furmint' was also characterised by the highest percentage of grafted vines with a partial developed callus in all rootstocks (on average 45%; in 'Börner' rootstock 49%). This can be considered typical for this variety, especially in years when weather conditions (tab. 1) are not suitable for wood maturation (e.g. in 2004). In this year in May the average monthly temperature was almost three degrees below as is the average for decade 2000–2009. The vegetation has been delayed more in the autumn, which were not favourable conditions for ripening of late varieties in general.

Table 1. The average monthly and growing season temperatures (GSTavg) for the Maribor meteorological station (2000–2009), and the recommended harvest dates (day in year) of the late ripening variety 'Furmint'

Month	Year										Average
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
April	14.1	9.8	10.0	10.0	10.9	11.0	11.6	13.7	11.0	13.7	11.6
May	17.1	17.4	17.8	18.5	13.9	16.2	15.2	17.2	16.9	17.1	16.7
June	21.1	18.1	21.5	23.5	18.4	19.6	19.7	21.2	20.2	18.5	20.2
July	20.0	21.7	21.9	22.7	20.5	20.7	23.4	22.4	21.3	21.5	21.6
August	22.4	22.0	20.3	24.4	20.8	18.1	17.8	20.2	20.7	21.2	20.8
September	16.0	13.7	14.9	15.4	15.5	16.1	17.4	14.0	14.9	17.1	15.5
October	12.6	13.8	11.1	8.6	12.3	11.1	12.9	9.5	11.6	10.6	11.4
GSTavg	17.6	16.6	16.8	17.6	16.0	16.1	16.9	16.9	16.7	17.1	16.8
Harvest date	255	275	288	253	297	282	271	262	266	265	271

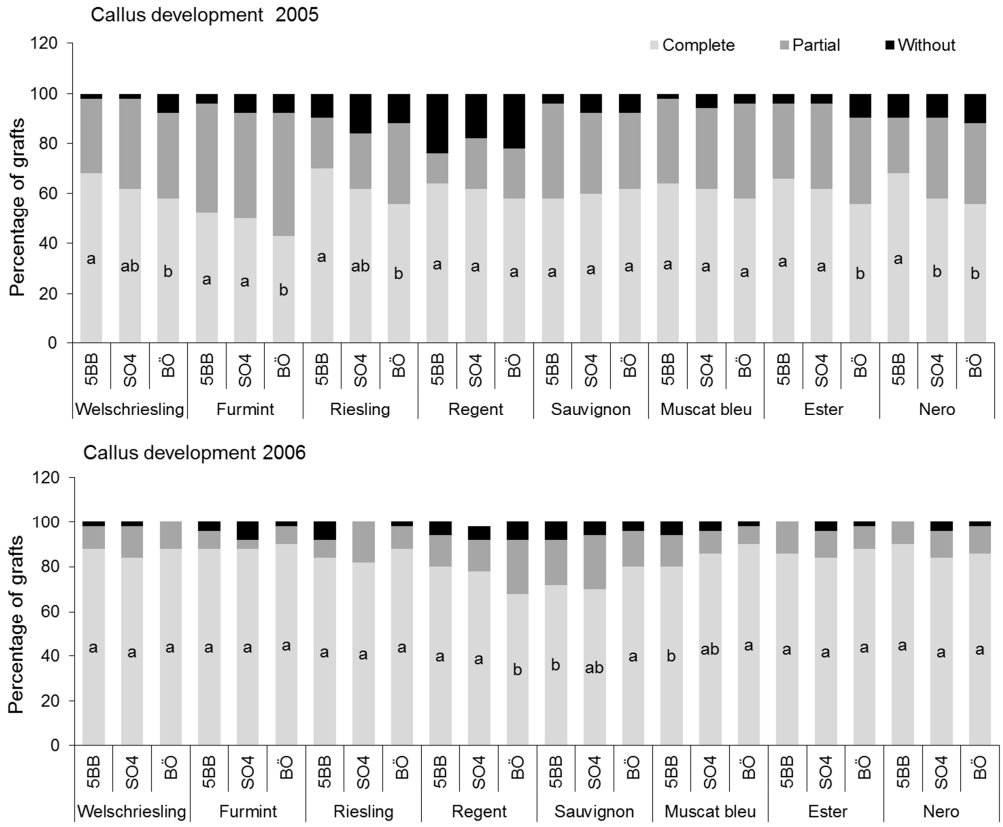

Fig. 1. Percentage of grafts with complete, partial and without developed callus of the wine- and table-grape varieties on the rootstocks '5BB', 'SO4', and 'Börner' (BÖ) after the forcing in 2005 and 2006. Statistical differences are marked only for the percentage of grafts with complete callus. Different letters indicate significant differences among the rootstocks $P \leq 0.05$

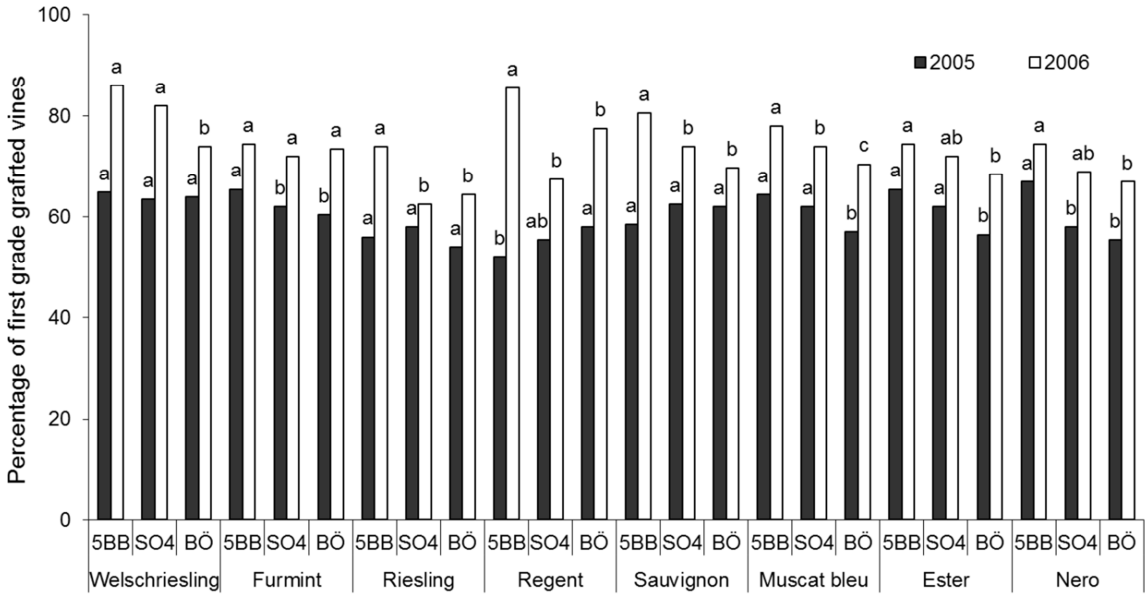

Fig. 2. Average percentage of first grade grafted vines of the wine- and table-grape variety on the rootstocks '5BB', 'SO4', and 'Börner' BÖ after the one year of growth in field nursery in 2005 and 2006. Different letters indicate significant differences between the rootstocks in each variety $P \leq 0.05$

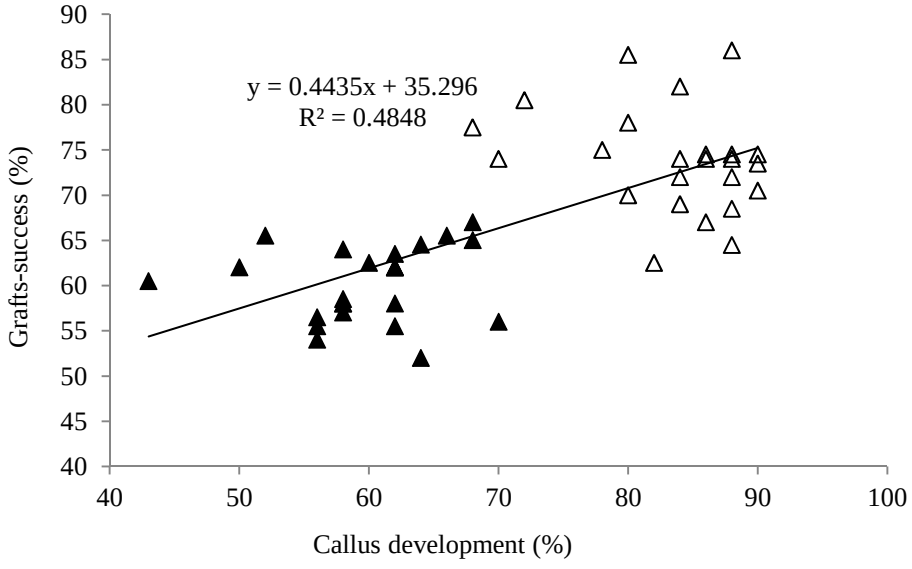

Fig. 3. Correlation between the percentage of grafted vines with complete developed callus and percentage of first grade grafted vines grafting success in 2005 black triangles and in 2006 white triangles $P \leq 0.05$

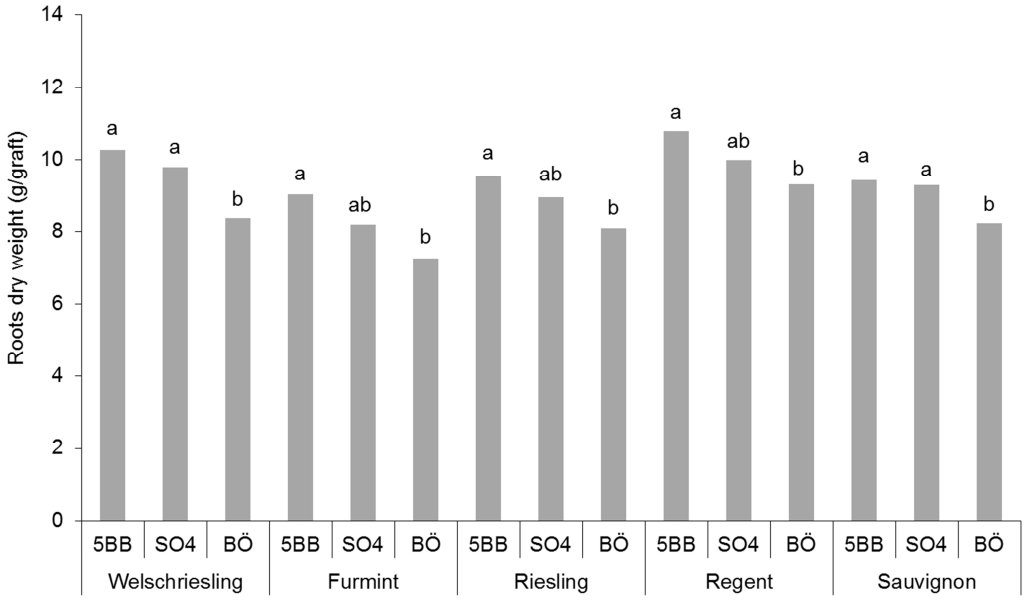

Fig. 4. Dry weight of adventitious roots in g per graft complete column of wine varieties on the rootstocks '5BB', 'SO4', and 'Börner' in 2006. Different letters indicate significant differences between the rootstocks in each variety $P \leq 0.05$

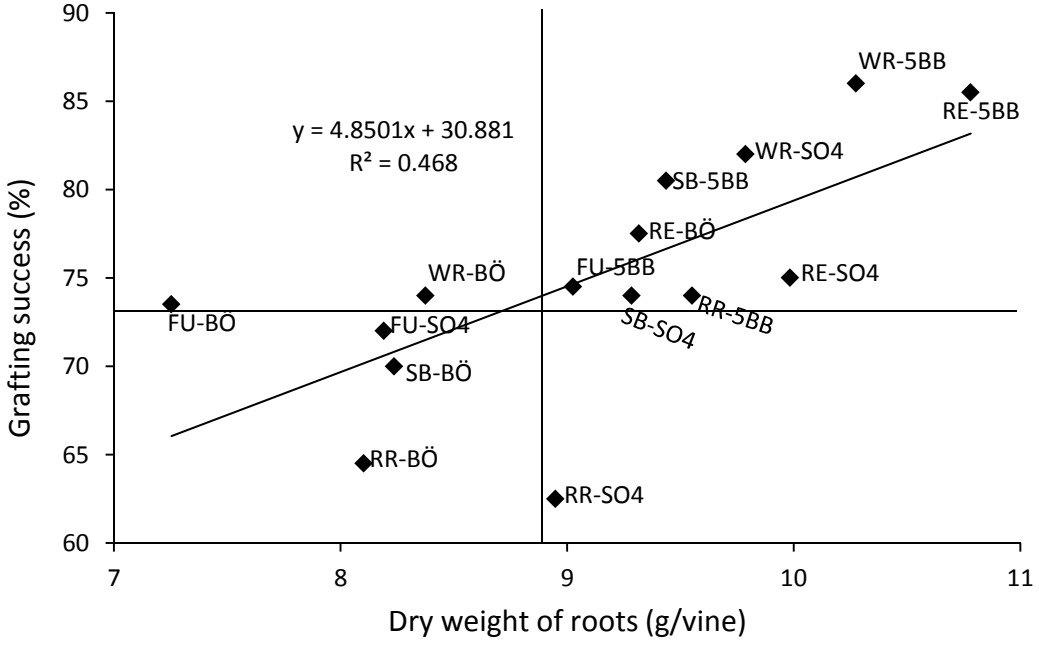

Fig. 5. Correlation between the root dry-weight g/graft and the first grade of grafted vines % of wine varieties 'Welschriesling' (WR), 'Furmint' (FU), 'Riesling' (RR), 'Sauvignon Blanc' (SB) and 'Regent' (RE) grafted on the '5BB', 'SO4', and 'Börner' (BÖ) rootstocks in the nursery in 2006 $P \leq 0.05$

The average percentage of grafted vines in 2005, with a completely developed callus was 8% higher when '5BB' rootstock was used (in comparison with 'Börner'), except for 'Sauvignon Blanc', 'Regent', and 'Muscat Bleu', where no significant differences were established. The greatest differences among rootstocks were observed on 'Riesling' (14%) grafted onto the '5BB' and 'Börner' rootstocks. The significant difference between '5BB' and 'SO4' was observed only in the 'Nero' table grape variety ($P \leq 0.05$). After callusing period in 2006, the differences in average percentage of grafted vines with completely developed callus between the '5BB' and 'Börner' rootstocks (fig. 1) were significant only in 'Regent', 'Sauvignon Blanc', and 'Muscat Bleu' varieties ($P \leq 0.05$). 'Sauvignon Blanc' and 'Muscat Bleu' had a higher percentage of grafted vines with a completely developed callus on the 'Börner' rootstock, which was not reflected later on the percentage of first grade of grafted vines in the field nursery. In 2006 in 'Furmint' the percentage of grafted vines with a partial developed callus was only 7% compared to 45% in 2005.

PERCENTAGE OF FIRST GRADE GRAFTED VINES

The differences between the rootstocks in the average percentage of the first grade grafts (fig. 2) were more consistent in table grape varieties. In comparison with 'Börner' the average percentage was significantly higher in both years, when the '5BB' rootstock was used. In wine varieties in 2005 the percentage was higher at the '5BB' rootstock only in 'Furmint'. 'Regent' had the highest percentages on the 'Börner', while in other varieties the differences between the rootstocks were not significant ($P \leq 0.05$). The percentages of the first grade grafts varied from 52% in 'Regent' to 67% in the table grape variety 'Nero', both on the '5BB' rootstock. The average percentage of first grade grafted vines (of all studied varieties) was 60%, and ranged from 58.4% in 'Börner' to 61.7% in '5BB'.

In 2006, the differences between the rootstocks were more consistent in all varieties and the average percentage varied from 62% in 'Riesling' on 'SO4' to 86% in 'Welschriesling' on '5BB'. The differences between '5BB' and 'Börner' were significant in all varieties, except in 'Furmint' ($P \leq 0.05$). In 2006, the average percentage was higher by 13.5% (it was 73.5%), and it varied from 70.6% in 'Börner' to 78.4% in '5BB'. In the case of 'Börner', the average percentage of the first grade grafts of all varieties was lower in both years, with 58.4% in 2005 and 70.6% in 2006. Its lower number of roots and reduced thickness (fig. 4) were mainly contributed to this reduced percentage of the first grade grafts. The correlation between the percentage of grafted vines with completely developed callus and percentage of first grade of grafts ($R^2 = 0.4825$) confirmed the results in Figure 3 and in the earlier studies [Vršič et al. 2009]. Differences between years are also reflected in this correlation. In 2005 the percentage of grafting success and grafts with completely developed callus in the most of grafted combinations were below 70%, while in 2006 most of them were exceeded 70% (fig. 3). The differences in the average percentage of the first grade grafts between the years were more consistent in the table grape varieties, which ripen earlier and the wood maturity is more appropriate.

Root development

In 2006, in the case of wine varieties (grafts of table grape varieties were planted in the next experiment in orchard) the differences in root development among '5BB' and 'Börner' rootstocks were significant ($P \leq 0.05$). In grafting combinations when '5BB' was used as rootstock – two-thirds of its grafts had four or more roots, which was resulted in a higher dry weight of roots per graft (fig. 4). In the 'Börner' rootstock were the grafts at the other extreme with only one-third of the grafts having four or more roots, while the other two-thirds had three roots (the accepted minimum). The 'SO4' rootstock had a significantly higher dry weight of roots per graft than 'Börner' only in combination with 'Welschriesling' and 'Sauvignon'($P \leq 0.05$). It was indicated that the loamy soils in our experimental conditions may have impacted 'Börner' rootstock which had fewer and thinner roots. This has a direct impact on the lower

percentage of first grade grafts, and lower dry weight of roots, resulting in the smaller amount of reserve substances in the grafts, which may have negatively influenced their growth in the first year after the planting in the vineyard [Vršič et al. 2009]. This conclusion was supported by the dry weight of roots per first grade grafts (fig. 4). Pavloušek (2010) also reported that in similar pedological conditions, in this rootstock the chlorosis (iron deficiency) may occur.

Thus, the main reason for the lower percentage of first grade grafted vines in 'Börner' rootstock was less developed root system per graft, which confirms also the correlation between the dry weight of roots and the first grade of grafted vines (R^2 = 0.468) (fig. 5). All combinations with 'Börner' rootstock were below the average of dry weight of roots of trials except for 'Regent', while with '5BB' rootstock they were above the average. Lower grafting success of 'Börner' rootstock in loamy soil is more result of less developed root system per graft as compatibility with different varieties. Root development of different vine rootstocks has an important impact on the water and nutrient uptake and accumulation of reserve substances, and their translocation to the shoots [Somkuwar et al. 2012].

Due to resistance against phylloxera and tolerance to viruses which are transmitted by nematodes [Blank et al. 2009], the 'Börner' rootstock is suitable for stock plantations to produce scions. Therefore, the 'Börner' rootstock is also considered to have the most potential as a donor of resistance against phylloxera in new cross-breeding.

CONCLUSION

The 'Börner' rootstock had similar compatibility with the wine and table grape varieties as 'SO4' and '5BB' rootstocks. The differences in callus development at the graft union were greater between the years than among rootstocks. Partly developed callus was most obvious in the late-ripening wine-grape variety 'Furmint' in all rootstocks. The differences in callus development between the years were confirmed with 24% more grafts with a completely overgrown callus in 2006 than in 2005. In both years the differences were more consistent in the table grape varieties, which ripen earlier and the wood maturity is more appropriate. Grafting success of 'Börner' rootstock in loamy soil is more result of less developed root system per graft as compatibility with different varieties.

ACKNOWLEDGMENTS

The author would like to thank the nurseries in north eastern Slovenia in which the trials were established, and the Ministry of Agriculture and Environment and the Ministry of Education, Science and Sport of Republic of Slovenia for financial support for this project (CRP: V4–0739).

REFERENCES

Benheim, D., Rochfort, S., Robertson, E., Potter, I.D., Powell, K.S. (2012). Grape phylloxera (*Daktulosphaira vitifoliae*) – a review of potential detection and alternative management options. Ann. Appl. Biol. 161, 91–115.

Blank, L., Wolf, T., Eimert, K., Schroder, M.B. (2009). Differential gene expression during hypersensitive response in phylloxera–resistant rootstock 'Börner' using custom oligonucleotide arrays. J. Plant Interact. 4, 261–269.

Cookson, S., Hevin, J.C., Donnart, M., Ollat, N. (2012). Grapevine rootstock effects on scion biomass are not associated with large modifications of primary shoot growth under non limiting conditions in the first year of growth. Funct. Plant Biol. 39, 650–660.

El-Nady, M.F. (2001). Untersuchungen zum Mechanismus der Reblausresistenz der Unterlagsrebsorte 'Börner'. PhD, Johannes Gutenberg-Universität, Mainz, Germany.

Gökbayrak, Z., Söylemezoğlu, G., Akkurt, M., Çelik, H. (2007). Determination of grafting compatibility of grapevine with electrophoretic methods. Sci. Hortic., 13, 343–352.

Granet, J., Kocsis, L. (2000). Populations of grape phylloxera gallicoles on rootstock foliage in Hungary. Vitis, 39, 37–41.

Granett, J., Kocsis, L., Horvath, L., Horvathne, E.B. (2005). Grape phylloxera gallicole and radicicole activity on grape rootstock vines. HortScience, 40, 150–153.

Granett, J., Walker, M.A., Kocsis, L., Omer, A.D. (2001). Biology and management of grape phylloxera. Annu. Rev. Entomol., 46, 387–412.

Kocsis, L., Granett, J., Walker, M.A. (2002). Performance of hungarian phylloxera strains on *vitis riparia* rootstocks. J. Appl. Entomol. 126, 567–571.

Korosi, G.A., Powell, K.S., Clingeleffer, P.R., Smith, B., Walker, R.R., Wood, J. (2011). New hybrid rootstock resistance screening for phylloxera under laboratory conditions. Acta Hortic., 904, 53–58.

Martinez-Peniche, R. (1999). Effect of different phylloxera *Daktulosphaira vitifoliae* Fitch populations from south France, upon resistance expression of rootstocks 41 B and Aramon × Rupestris Ganzin No. 9. Vitis, 38, 167–178.

Milien, M., Renault-Spilmont, A.S., Cookson, S.J., Sarrazin, A., Verdeil, J.L. (2012). Visualization of the 3D structure of the graft union of grapevine using X-ray tomography. Sci. Hortic. 144, 130–140.

Patil, S.G., Karkamkar, S.P., Deshmukh, M.R. (2005). Screening of grape varieties for their drought tolerance. Indian J. Plant Physiol. 10, 176–178.

Pavloušek, P. (2009). Evaluation of lime-induced chlorosis tolerance in new rootstock hybrids of grapevine. Eur. J. Hortic. Sci., 74, 35–41.

Pavloušek, P. (2010). Lime-induced chlorosis and drought tolerance of grapevine rootstocks. Acta Univ. Agric. Silvic. Mendel. Brun., 58, 431–440.

Pavloušek, P. (2011). Evaluation of drought tolerance of new grapevine rootstock hybrids. J. Env. Biol., 32, 543–549.

Pavloušek, P., Michlovsky, M. (2007). Breeding of grapevine rootstocks in the Czech Republic. XXXth OIV World Congress of Vine and Wine, Budapest 10–16 June 2007, 1–5.

Pellegrino, A., Lebon, E., Simmoneau, T., Wery, J. (2005). Towards a simpleindicator of water stress in grapevine *Vitis vinifera* L. based on the differential sensitivities of vegetative growth component. Aust. J. Grape Wine Res., 11, 306–315.

Pire, R., Pereira, A., Diez, J., Fereres, E. (2007). Drought tolerance assessment of a Venezuelan grape rootstock and possible conditions mechanism. Agrociencia, 47, 435–446.

Pina, A., Erra, P. (2005). A review of new advances in mechanism of graft compatibility-incompatibility. Sci. Hortic., 106, 1–11.

Rühl, E.H., Bleser, E., Maunty, F., Schmid, J. (1999). Unterlagenzüchtung in Geisenheim. 19. Internationale Geisenheimer Rebveredlertagung 1998. Geisenheimer Berichte, 40, 101–105.

Somkuwar, R.G., Taware, P.B., Bondage, D.D., Navale, S. (2012). Root length, root mass, and distribution of dry matter in different parts of Thompson Seedless grapevine grafted on different rootstocks in heavy soil of Maharashtra. Turk. J. Agric. For. 36, 543–552

Schmid, J., Manty, F. (2009). Zwei Standorte und Unterlagen im Test. Dtsch. Weinbau, 23, 12–16.

Tandonnet, J.P., Cookson, S.J., Vivin, P., Ollat, N. (2009). Scion genotype controls biomass allocation and root development in grafted grapevine. Aust. J. Grape Wine Res., 16, 290–300.

Tarricone, L., Masi, G., Gentilesco, G., Amendolagine, A.M. (2011). Effects of rootstock on nursery performance of seedless table grapes. Riv. Vitic. Enol., 64, 73–81.

Vršič, S., Pulko, B., Valdhuber, J. (2009). Influence of defoliation on carbohydrate reserves of young grapevines in the nursery. Eur. J. Hortic. Sci., 74, 218–222.

Vršič, S., Šuštar, V., Pulko, B., Kraner-Šumenjak, T. (2014). Trends in climate parameters affecting wine--grape ripening in northeastern Slovenia. Clim. Res., 58, 257–266.

Zhang, J., Hausmann, L., Eibach, R., Welter, L.J., Töpfer, T., Zyprian, E.M. (2009). A framework map from grapevine V3125 *Vitis vinifera* Schiava grossa × 'Riesling' × rootstock cultivar 'Börner' *Vitis riparia* × *Vitis cinerea* to localize genetic determinants of phylloxera root resistance. Theor. Appl. Genet., 119, 1039–1051.