Scientia Horticulturae 181 (2015) 168–173

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Factors influencing grafting success and compatibility of grape rootstocks

Stanko Vršič[a,*], Borut Pulko[a], Laszlo Kocsis[b]

[a] Faculty of Agriculture and Life Sciences, Pivola 10, SLO-2231 Hoče, Slovenia
[b] Georgikon Faculty, 16 Deak F. Str., H-8360, Keszthely, Hungary

ARTICLE INFO

Article history:
Received 7 August 2013
Received in revised form
16 September 2014
Accepted 31 October 2014
Available online 25 November 2014

Keywords:
Grapevine
Compatibility
Rootstock
Graft
Shoot growth
Root development

ABSTRACT

The aim of this work was to examine the compatibility of different rootstocks with various wine grape varieties. In the first trial, *Vitis vinifera* L. cvs. Furmint, Regent, Riesling, Sauvignon Blanc, and Welschriesling were grafted onto Börner, 5BB and SO4 rootstocks. In the second trial Welschriesling was grafted on 12 rootstocks. Their growth during the first year in the vineyard was measured. As an index of compatibility, the percentage of first grade grafted vines as well as dry weight of mature shoots (canes) and roots was determined. After the grafts went through the first phase of healing often called callusing (2–3 weeks of moist warm conditions), the differences in callus formation were greater between years than among rootstocks, which were the most obvious with Furmint as a scion. No good callus formation occurred when cane (rootstock, scion) maturity is not adequate. Such was the case in 2005, there were 24% fewer grafts with fully developed callus than those in 2006. The dry weight of roots was higher on 5BB than on Börner and SO4. Börner rootstock had fewer roots, and the roots were thinner. Welschriesling had good compatibility with all rootstocks (the average grafts success was 67%), but that of 5BB, G251, and G103 (above 80%) was greater than the average. The G103 rootstock had the highest dry weight of roots. Shoot growth in vineyards was above the average with 5BB, SO4, Binova, Börner, and M V rootstocks. All Georgikon rootstocks had a lower cane dry weight per vine than the others.

1. Introduction

In the second half of the 19th century the phylloxera (*Daktulosphaira vitifoliae* Fitch) was inadvertently introduced to Europe and gradually destroyed European vineyards (Granett et al., 2001). Grape rootstocks were selected from North American *Vitis* sp., and later hybrids were made among them to manage the problem. However, phylloxera has been evolving more aggressive strains that can overcome the resistance of some rootstocks (Martinez-Peniche, 1999), and damage due to phylloxera is increasing in some areas (Rühl et al., 1999). Despite this fact the grafting of vine varieties on American rootstocks is still considered to be the most effective means of controlling phylloxera.

Given phylloxera's ability to develop more aggressive strains, rootstock breeders must test new rootstocks against this pest (Korosi et al., 2011). At the end of the 1990s, several German vineyards were replanted with vines grafted on Börner rootstock (Becker, 1989; Basler, 1994; Hafner, 1998). Börner was selected from the hybrid progeny derived from crossing *Vitis riparia* 183 Gm × *Vitis cinerea* Arnold (Ambrosi et al., 1994). This rootstock has a strong hypersensitive reaction to phylloxera attack (Blank et al., 2009), and is considered to have one of the highest levels of resistance among commercially used rootstocks (Pavloušek and Michlovský, 2007). However, it is susceptible to lime-induced chlorosis and difficult to propagate (Vršič et al., 2004; Pavloušek, 2009, 2010).

When new rootstocks are bred and selected a number of traits need to be evaluated in addition to phylloxera resistance such as: their affinity and compatibility, vigour (Pellegrino et al., 2005), and adaptation to soils and climatic conditions (Patil et al., 2005; Pire et al., 2007; Pavloušek, 2011). The mechanism of graft incompatibility is not fully understood. Researchers have studied how the union develops and functions over time (Pina and Errea, 2005; Darikova et al., 2011), and have confirmed that there is an incompatibility between different scion-rootstock combinations (Gökbayrak et al., 2007). This incompatibility can be detected a few weeks after grafting by a poor vascular connection and phloem degeneration at the graft union. These vascular fusion problems can disturb water,

* Corresponding author at: University of Maribor, Faculty of Agriculture and Life Sciences, Pivola 10, 2311 Hoce, Slovenia. Tel.: +386 2 320 9046; fax: +386 2 616 11 58.
E-mail address: stanko.vrsic@um.si (S. Vršič).

http://dx.doi.org/10.1016/j.scienta.2014.10.058
0304-4238/

Table 1
Bioclimatic parameters (GDD, HI, GSTavg and GSP) for the Maribor meteorological stations (2000–2009) and the recommended harvest date of the late ripening variety Furmint.

Year	GDD	HI	GSTavg	GSP	Harvest date
2000	1655	2173	17.6	428	255
2001	1477	1897	16.6	603	275
2002	1518	1988	16.8	568	288
2003	1774	2353	17.6	454	253
2004	1351	1785	16.0	639	297
2005	1370	1815	16.1	778	282
2006	1510	1952	16.9	588	271
2007	1532	2103	16.9	627	262
2008	1468	1961	16.7	592	266
2009	1574	2094	17.1	851	265
Average	1522	2003	16.8	613	271

GDD, growing degree days; HI, Huglin index; GSTavg, average growing season temperature; GSP, growing season precipitations; Harvest date, day in year.

nutrient, and assimilate flows in the plant and may result in further breakdown of the union (Pina et al., 2009). X-ray tomography has been used to evaluate graft quality and found that the good grafts had well-connected tissues in the wood and phloem, while the bad grafts had not completely connected (Milien et al., 2012). Others found that phenol accumulation below and above the graft union might serve as an indicator of incompatibility (Usenik et al., 2006). In Slovenia and Hungary, new rootstock cultivars are being developed to improve phylloxera resistance and site adaptability. This study was designed to test the compatibility of these rootstocks with the main Slovenian grape cultivars.

2. Materials and methods

In the first trial in 2005 and 2006 (trial one), the *Vitis vinifera* L. cvs. Furmint, Regent, Riesling, Sauvignon Blanc, and Welschriesling were grafted onto Börner rootstock and were compared with 5BB and SO4. The canes of scions and rootstocks for trial one were collected in the collection vineyard at the University Centre of Meranovo, Faculty of Agriculture and Life Sciences, in Slovenia. Riesling and Sauvignon Blanc are international varieties and also very important in Slovenian viticulture. Furmint is a very late ripening variety. The late harvest date (such as in 2004, Table 1) lead to poor cane maturity, which has an impact on the graft success. Regent is in the process of introduction to the Slovenian grapevine list. Welschriesling is the main wine grape variety in Slovenia and Hungary. In the second trial (trial two) the Welschriesling was grafted onto twelve rootstocks in 2011, namely 5BB, SO4-31, Börner and Binova (from UC Meranovo), G103, G203, G216, G251 (from Department of Horticulture of Georgikon Faculty in Keszthely, Hungary), and M VI, 8 BČ, M V (Slovenian clones of *Vitis berlandieri* × *V. riparia*). Rootstock candidates provided by the Georgikon Faculty have strengthened phylloxera resistance and drought and lime tolerance according to the breeders, but limited information is available about their interaction with scions. Two of them (G103 and G203) are a complex hybrid of riparia–rupestris–berlandieri–vinifera, G216 is Georgikon 28 × Teleki 5C crossbred, and G251 is Georgikon 28 × Börner hybrid. In trial two in the nursery, the shoot growth, and the cane and roots dry weight of these twelve combinations was measured.

Prior to grafting, the cuttings of rootstocks (35 cm length) and scions were disinfected in a 0.5% solution of Chinosol W (8-quinoline sulphate) and kept in plastic bags at 2 °C. In total, 200 scions of each variety were grafted onto each rootstock. Grafting was done by the 'omega' technique (Becker, 1989). Grafts were callused (healed) in moist sawdust at a temperature of 26–28 °C, and with humidity of about 80–90%. The grafted rootstock/scion units were waxed twice: 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 plastic row cover (0.5 mm thickness). The trial one, based on a randomised, complete block design with four replications, included 50 grafted units per replicate, while the trial two was designed in randomised groups. The trials were conducted in a commercial nursery near Ptuj (46°46′ N, 15°81′ E, 280 m.a.s.l) in NE 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 compatibility of the grafted units was analysed by the degree of callus development, the shoot growth, the percentage of first grade grafted vines (Council Directive 68/193/EEC and Official Gazette of RS, no. 93/05), and the dry weight of mature shoots (canes) and roots. To evaluate the success of grafting, the level of callus development around the graft union was determined. After the callusing period, the grafted vines were divided into three groups: (1) vines with a completely developed callus; (2) vines with a partially developed callus; and (3) vines without a callus. After a season of growth in the nursery field, the grafted plants were undercut and lifted from the soil. At this point the healing of the graft union, and extent of the root system was evaluated. The first grade grafted vines had at least three equally developed roots that were thicker than 3 mm (the accepted minimum; Official Gazette of RS, no. 93/05). In trial one in 2006, the first grade grafted vines were divided into two groups: those with three roots, and those with four or more roots.

For the second test examining Welshriesling grafted on 12 rootstocks, all combinations grafted in 2011 were planted in a vineyard in 2012, with 25 plants per each rootstock. The shoot growth and dry weight of canes was measured (all 25 plants in replicate were included for these evaluations). At the end of the growing season the canes and roots were dried at 105 °C to determine their dry weight.

For the statistical analysis of the data, the programme SPSS 19.0 was used (ANOVA – analysis of variance, $P < 0.05$).

3. Results and discussion

3.1. Callus development

After the callusing period, callus development was evaluated at the graft union (Table 2). The percentage of completely developed callus across all grafted vines was 82% in 2006, which was 23% higher (20% with 5BB, 21% SO4, 27% with Börner) than in the previous year (in 2005 was 59% in all across combinations). This reduced graft success in 2005 could have been due to poor cane maturity in 2004, as a result of very late harvest date in 2004 (Table 1). Healing is a complex biochemical and structural process from the surface cut until the functional vascular system establishment (Pina and Errea, 2005). Furthermore, graft compatibility could have been reduced due to the limited peroxidase enzyme activity and limited level of polymerisation of p-coumaryl alcohols to lignin (Pederson, 2006). The greatest difference in callus development between the years was determined for Furmint (40%). The average percentage of grafted vines in 2005 with a completely developed callus was 7% higher when 5BB was used (in comparison with Börner), except for Sauvignon Blanc and Regent, where no significant differences were established. The greatest difference among rootstocks was observed on Riesling (14%) grafted onto the 5BB and Börner. In 2006, the differences in completely developed callus between the 5BB and Börner rootstocks (Table 2) were significant only in Regent and