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The effect of different scion/rootstock combinations on yield properties of cv. `Cabernet Sauvignon`

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ABSTRACT

The yield properties of different scion/rootstock combinations for cv. `Cabernet Sauvignon` (*Vitis vinifera* L. cv. `Cabernet Sauvignon`) were evaluated. The experiment was set in the Vipava Valley as a randomised group trial. The planting material was cv. `Cabernet Sauvignon` standard selected in Slovenia and clones 191 and 15 of French selection. The rootstocks inspected in the combinations with scions were `Kober 5BB`, `SO 4` and `420 A Mgt` (*V. berlandieri* Planch. x *V. riparia* Michx.), `1103 Paulsen` (*V. berlandieri* Planch. x *V. rupestris* Scheele.) and `3309 Couderc` (*V riparia* Michx. x *V. rupestris* Scheele.). The vines were trained on double Guyot and monitored during 2001 and 2002. At the harvest the yield/vine and number of bunches/vine were recorded and the sample of 100 berries/vine was taken. The samples of berries were weighed and analysed for grape sugar and acids content. During the dormant season one-year-old canes were weighed. Data were statistically analysed using the one-way analysis of variance. The standard material showed greater vegetative and productive potential than cl. 191 when both were grafted onto `SO 4`. The consequence was lower grape quality for standard. Although the differences in productivity and grape quality between standard grafted onto different rootstocks were not significant it was obvious that `1103 Paulsen`, in comparison with `SO 4` and `420 A Mgt`, significantly increased the vegetative growth of scion. The difference in the yield/vine between standard grafted onto `Kober 5BB` and cl. 15 grafted onto `3309 Couderc` was unstable but with the former combination better grape quality was achieved and one fold higher pruning weight/vine was detected in both years.

Key words: grapevine, Cabernet Sauvignon, scion, rootstock, grape quality

IZVLEČEK

VPLIV RAZLIČNIH KOMBINACIJ CEPIČ/PODLAGA NA LASTNOSTI PRIDELKA SORTE `CABERNET SAUVIGNON`

V poskusu smo proučevali vpliv različnih kombinacij cepič/podlaga na lastnosti pridelka sorte `Cabernet Sauvignon` (*Vitis vinifera* L.). Poskus smo izvedli v vinorodnem okolišu Vipavska dolina v poskusni zasnovi slučajne skupine. Sadilni material je bil standard sorte `Cabernet

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Sauvignon` selekcioniran v Sloveniji in klona 191 in 15 selekcionirana v Franciji. Podlage, ki smo jih uporabili v kombinaciji s cepiči so bile `Kober 5BB`, `SO 4`, `420 A Mgt` (*V. berlandieri* Planch. x *V. riparia* Michx.), `1103 Paulsen` (*V. berlandieri* Planch. x *V. rupestris* Scheele.) in `3309 Couderc` (*V riparia* Michx. x *V. rupestris* Scheele.). Gojitvena oblika je bila dvojni Guyot. Poskus smo izvedli v letih 2001 in 2002. Ob trgatvi smo izmerili težo pridelka in prešteli število grozdov na trto ter vzorčili 100 jagod. Vzorce smo stehtali in v grozdnem soku določili vsebnost sladkorjev in kislin. V času mirovanja smo porezali in stehtali enoletni les. Podatke smo statistično obdelali z enosmerno analizo variance. Primerjava standarda in klona 191 cepljenih na podlago `SO 4` je pokazala večji rastni in produktivni potencial za standard. Posledica je bila slabša kakovost grozdja pri standardu. Razlike v rodnosti in kakovosti grozdja med standardom na različnih podlagah niso bile značilne, vendar je podlaga `1103 Paulsen` značilno povečala vegetativno rast trt v primerjavi s podlagama `SO 4` in `420 A Mgt`. Razlika v pridelku na trs med standardom cepljenim na `Kober 5BB` in klonom 15 cepljenim na `3309 Couderc` je bila spemenljiva, vendar smo s prvo kombinacijo dobili boljšo kakovost grozdja. Prav tako so imele trte te kombinacije enkrat večjo težo porezanega enoletnega lesa v obeh letih.

Ključne besede: vinska trta, Cabernet Sauvignon, cepič, podlaga, kakovost grozdja

1 INTRODUCTION

Although the threat of phylloxera (*Daktulosphaira vitifoliae* Fitch) remains one of the most important reasons for grafting, the rootstocks enable cultivars to grow in different environmental conditions. In addition, some cultivar characteristics are modified by interaction with the rootstock (Branas, 1974; Galet, 1988; Jackson, 2000). One of the problems when choosing the right scion/rootstock combination is in predicting how the scion and rootstock will interact. Interaction results from the mutual translocation of nutrients and growth regulators between the scion and rootstock (Jackson, 2000). The influence of rootstocks on yield parameters and physiology of cv. `Cabernet Sauvignon` and other cultivars was already reported (Scienza et al., 1980; Williams and Smith, 1991; Peterlunger et al., 1998; Bica et al., 2000; Ollat et al., 2003). The results of the studies also suggested that rootstocks differed in root distribution pattern and total root number what influenced the yield and pruning weight/vine and their ratio (Morano and Kliewer, 1994; Ollat et al., 2003). The climatic and soil conditions can modify the expression of both rootstock and scion traits, therefore their interaction may vary from year to year (Zulini et al., 2002) and from location to location. Thus, the applicability of particular rootstock must be assessed based on local experiences. A few results for nursery and vine growing standards of different scion/rootstock combinations are already available in Slovenia (Tozan et al., 1998; Lavrenčič et al., 2003) but more investigations in productive vineyards are needed.

For the lower part of the Vipava Valley heavy loamy clay soil with relative good water holding capacity is characteristic (Stritar, 1991). The average rainfall during the growing season (1st of April to 30th of September) is 750 mm. In some years summer droughts may occur and therefore the drought resistant rootstocks are desired. By contrast, in very wet conditions provoked with higher spring and summer rainfall, vigorous growth may appear, thus rootstocks that retard the scion's growth are preferred. Cv. `Cabernet Sauvignon` is beside cv. `Merlot` and cv. `Refošk` the most important red cultivar in the Primorska wine growing region (Škvarč et al., 2002). The main viticulture difficulties of its cultivation are possible vigorous growth, quite late ripening and bell-pepper aroma of the wines produced under less favourable

conditions. Therefore controlling the vine vigour, acceptable drought tolerance and an earlier grape ripening are the main vine growing goals of proper scion/rootstock selections for cv. `Cabernet Sauvignon` in the environment of the Primorska wine growing region.

The aim of our study was to investigate the yield characteristics of different scion/rootstock combinations for cv. `Cabernet Sauvignon` in the defined vineyard environment.

2 MATERIALS AND METHODS

The trial was conducted in the vineyard of cv. `Cabernet Sauvignon` planted in 1996 and located in the lower part of the Vipava Valley wine growing district (AV Kromberk, Biotechnical Faculty). The vines were monitored during the growing seasons 2001 and 2002. The planting material was cv. `Cabernet Sauvignon` standard selected in the positive mass selection in Slovenia and the clones 191 and 15 of French selection. Cv. `Cabernet Sauvignon` cl. 15 belongs to the ENTAV 1 selection and in the group C of clones with regard to their production capacity (high to very high productivity). It has superior fertility, medium bunch weight and grape sugar content. Cl. 191 belongs to the INRA-Bx 2814 selection and in the group A with regard to the production capacity (limited productivity). It has medium fertility and bunch weight but superior grape sugar content (ENTAV et al., 1995). The standard material in the experimental vineyard represented the progeny of the some vines involved in the positive mass selection in Slovenia (Koruza et al., 2003). The rootstocks inspected in the combinations with scions were `Kober 5BB`, `SO 4`, `420 A Mgt` (all *V. berlandieri* x *V. riparia* crossings), `1103 Paulsen` (*V. berlandieri* x *V. rupestris*) and `3309 Couderc` (*V riparia* x *V. rupestris*). Different scion/rootstock combinations were planted in rows in randomised group design. The spacing between rows and vines in the vineyard was 2.3 x 1.0 m (row x vine). A single vine was planted per site. Vines were trained on double Guyot and normally pruned: two yielding canes per vine with eight buds/cane and one renewal spur with two buds. The vineyard was ploughed two times a year (in spring and at the end of the growing season) and was not irrigated. Considering the climatic conditions, 2001 could be regarded as exceptional year for this region with lower than normal but sufficient rainfall and very favourable temperatures during the grape ripening (August). The year 2002 was quite regular with the average sum of rainfall during the growing season and a lot of rainfall in August (Tab. 1 and 2) (ARSO, 2001-2002).

Table 1: Average monthly air temperatures (^{o}C) measured in Bilje (Nova Gorica)

		Deviation from 30-year average (^{o}C)	
Month	Average air temp. (^{o}C) 1961-1990	2001	2002
April	11.0	0.0	1.3
May	15.7	3.1	1.3
June	19.2	0.1	2.8
July	21.4	1.0	1.2
August	20.5	3.3	0.5
September	16.8	-1.6	-0.5

Table 2: Average monthly rainfall measured in Bilje (Nova Gorica)

		Deviation from 30-year average (mm)	
Month	Average rainfall (mm) 1961-1990	2001	2002
April	116.1	-26.1	-31.1
May	108.6	-44.6	-1.4
June	140.0	-49.0	-15.0
July	106.7	8.3	-44.7
August	131.0	-122.0	211.0
September	140.0	142.0	-22.0

The main factor of the experiment was either genetic material of scion or a rootstock. The following comparisons were done: in the first comparison the difference between cv. `Cabernet Sauvignon` standard and cl. 191 grafted onto `SO 4` rootstock was inspected; secondly, the impact of `SO 4`, `1103 Paulsen` and `420 A Mgt` rootstocks on the yield parameters of standard was evaluated, and finally, two scion/rootstock combinations were compared: cv. `Cabernet Sauvignon` standard grafted onto `Kober 5BB` vs. cv. `Cabernet Sauvignon` cl. 15 grafted onto `3309 Couderc`. For each scion/rootstock combination 10 vines were chosen in the plot.

At the harvest the yield per vine was weighed, the number of bunches per vine was counted and the sample of 100 berries per vine was taken. The samples of berries were weighed and analysed for grape sugar and acids content. Sugar content was measured with Digital vine refractometer WM-7 (Atago, Japan) in degrees Oe (^{o}Oe) and grape acids content was deduced by titration with 0.1 M NaOH to the pH 8.2 endpoint. During the dormant season, vines were pruned on a vine-by-vine basis. One-year-old canes were separated from the old wood and weighed. The pruning weights are reported with the data from the previous growing season. Ravaz index for each vine was calculated by dividing the yield per vine (kg) with the pruning weight per vine (kg). Data were statistically analysed using the one-way analysis of variance and means were separated using the Duncan's multiple range test at a significance of $p \leq 0.05$.

3 RESULTS AND DISCUSSION

The results of all listed parameters are presented for 2001, however, in 2002 the results for weight of 100 berries and grape sugar and acids contents are missing due to the lack of measurements.

The results in the Tab. 3 display the differences in the yield properties between cv. `Cabernet Sauvignon` standard and cl. 191 grafted onto `SO 4`. In 2001 Slovene standard material had superior productive potential than French cl. 191 what was demonstrated in higher number of bunches/vine and bunch weight. The consequence was already one fold higher yield/vine, lower weight of 100 berries and grape sugar content together with higher acids content for standard. Although it had higher grape productivity the pruning weight was also higher what further influenced almost one fold higher Ravaz index in comparison to cl. 191.

Table 3: Yield properties of cv. `Cabernet Sauvignon` standard and cl. 191 grafted onto `SO 4` in 2001

Yield parameter	cv. `Cabernet Sauvignon` standard	cv. `Cabernet Sauvignon` cl. 191
Number of bunches	32.6a[1]	24.2b
Bunch weight (g)	171.5a	126.3b
Weight of 100 berries (g)	117.8a	122.4a
Yield/vine (kg)	5.5a	2.9b
Grape sugar content (^{o}Oe)	79.2a	82.4a
Grape acids content (g/l)	7.5a	6.9a
Pruning weight/vine (kg)	0.8a	0.7a
Ravaz index[2]	7.5a	4.3a

[1] means followed by the same letter were not significantly different ($p \leq 0.05$).
[2] statistic analysis was not done due to Ravaz index being a calculated parameter (it has to be considered in the following Tables).

The same was shown for harvest in 2002 (Tab. 4). Although the productivity was lower than in 2001 for both examined material the proportions between them were

similar as in 2001. Number of bunches/vine, bunch weight and yield/vine were higher for standard beside slightly lower pruning weight/vine. Ravaz index for standard was again nearly one fold higher than for cl. 191.

Table 4: Yield properties of cv. `Cabernet Sauvignon` standard and cl. 191 grafted onto `SO 4` in 2002

Yield parameter[1]	cv. `Cabernet Sauvignon` standard	cv. `Cabernet Sauvignon` cl. 191
Number of bunches	21.8a[2]	19.3a
Bunch weight (g)	149.2a	106.8b
Yield/vine (kg)	3.2a	2.1b
Pruning weight/vine (kg)	0.9a	1.0a
Ravaz index	4.3a	2.2a

[1] only parameters with 10 measurements are presented. For weight of 100 berries, grape sugar and acids contents only two measurements were done and this was considered as insufficient for conclusions.
[2] means followed by the same letter were not significantly different ($p \leq 0.05$).

The comparison of different grafting combinations for cv. `Cabernet Sauvignon` standard is shown in Tab. 5. The differences between the three rootstocks existed but they were not significant. The highest yield/vine was achieved with `SO 4` followed by `420 A Mgt` and `1103 Paulsen`. The differences were the result of different bunch weight between the rootstocks beside the similar number of bunches/vine. The weight of 100 berries was the highest for `1103 Paulsen` and almost the same for the other two rootstocks. The higher grape sugar content was reached with standard grafted onto `SO 4` followed by `1103 Paulsen` and `420 A Mgt`. The range for grape acids content was the same as for sugar content. Pruning weight/vine was the smallest for `SO 4` grafting and the same for the other two combinations. Ravaz index for `SO 4` was quite higher than for `420 A Mgt` and `1103 Paulsen`.

As was already shown in Tab. 4, the productivity of the vines in 2002 was lower than in 2001 for all three grafting combinations (Tab. 6). The range of the bunch weights in 2002 was the same as in 2001 but the differences in number of bunches/vine resulted in the highest yield/vine for `1103 Paulsen` followed by `SO 4` and `420 A Mgt`. The extent of difference from highest to lowest yield/vine in this year (0.5 kg) was almost the same as in 2001 (0.4 kg). The pruning weight for `1103 Paulsen` was significantly higher than for `SO 4` and `420 A Mgt`. Interestingly, the ratio of Ravaz indexes of `SO 4` vs. `1103 Paulsen` was the same in both years (1.4). Ravaz index for `420 A Mgt` in 2002 reached the level of `SO 4`.

Table 5: Yield properties of cv. `Cabernet Sauvignon` standard grafted onto `SO 4`, `1103 Paulsen` and `420 A Mgt` in 2001

Yield parameter	`SO 4`	`1103 Paulsen`	`420 A Mgt`
Number of bunches	32.6a[1]	34.4a	35.1a
Bunch weight (g)	165.1a	148.3a	153.9a
Weight of 100 berries (g)	117.8a	126.9a	118.8a
Yield/vine (kg)	5.5a	5.1a	5.3a
Grape sugar content (^{o}Oe)	79.2a	78.6a	77.5a
Grape acids content (g/l)	7.5a	7.3a	7.3a
Pruning weight/vine (kg)	0.8a	1.0a	1.0a
Ravaz index	7.5a	5.5a	5.7a

[1] means followed by the same letter were not significantly different ($p \leq 0.05$).

Table 6: Yield properties of cv. `Cabernet Sauvignon` standard grafted onto `SO 4`, `1103 Paulsen` and `420 A Mgt` in 2002

Yield parameter[1]	`SO 4`	`1103 Paulsen`	`420 A Mgt`
Number of bunches	21.8a[2]	24.8a	20.8a
Bunch weight (g)	149.2a	137.3a	139.3a
Yield/vine (kg)	3.2a	3.4a	2.9a
Pruning weight/vine (kg)	0.9a	1.3b	0.8a
Ravaz index	4.3a	3.0a	4.3a

[1] only parameters with 10 measurements are presented. For weight of 100 berries, grape sugar and acids contents only two measurements were done and this was considered as insufficient for conclusions.
[2] means followed by the same letter were not significantly different ($p \leq 0.05$).

In Tab. 7 the results for cv. `Cabernet Sauvignon` standard grafted onto `Kober 5BB` and cv. `Cabernet Sauvignon` cl. 15 grafted onto `3309 Couderc` in 2001 are presented. Although cl. 15 had a higher number of bunches/vine a significantly lower bunch weight and weight of 100 berries influenced 0.5 kg lower yield/vine. In spite of this also higher grape sugar content and lower acids content were demonstrated for standard. The outcome of very low pruning weight for cl. 15 was more than one-fold higher Ravaz index, which exceeded the values of all previously described combinations in 2001 (see also Tab. 3 and 5).

In 2002 (Tab. 2002) the difference in number of bunches/vine between standard and cl. 15 increased when compared to 2001 and it was significant. Higher rainfall in August 2002 (see Tab. 2) influenced lower difference in bunch weight when compared to 2001. The issue was a significantly higher yield/vine for cl. 15. The pruning weight for standard was more than one fold higher in comparison to cl. 15. Lower yield/vine and higher pruning weight/vine resulted in very low Ravaz index for standard and pointed to the disequilibria between growth and productivity. The consequence of higher yield/vine for cl. 15 was lower Ravaz index than in 2001 but it was again the highest one in comparison to the other grafting combinations.

Table 7: Yield properties of cv. `Cabernet Sauvignon` standard grafted onto `Kober 5BB` and cv. `Cabernet Sauvignon` cl. 15 grafted onto `3309 Couderc` in 2001

Yield parameter	cv. `Cabernet Sauvignon` standard/`Kober 5BB`	cv. `Cabernet Sauvignon` cl. 15/`3309 Couderc`
Number of bunches	29.4a[1]	35.0a
Bunch weight (g)	132.7b	100.7a
Weight of 100 berries (g)	117.7b	79.7a
Yield/vine (kg)	3.9a	3.4a
Grape sugar content (^{o}Oe)	81.4a	78.0a
Grape acids content (g/l)	7.2a	8.2a
Pruning weight/vine (kg)	0.8b	0.4a
Ravaz index	4.7a	10.4a

[1] means followed by the same letter were not significantly different ($p \leq 0.05$).

Table 8: Yield properties of cv. `Cabernet Sauvignon` standard grafted onto `Kober 5BB` and cv. `Cabernet Sauvignon` cl. 15 grafted onto `3309 Couderc` in 2002

Yield parameter[1]	cv. `Cabernet Sauvignon` standard/`Kober 5BB`	cv. `Cabernet Sauvignon` cl. 15/`3309 Couderc`
Number of bunches	21.0a[2]	28.6b
Bunch weight (g)	134.3a	131.1a
Yield/vine (kg)	2.8a	3.8b
Pruning weight/vine (kg)	1.3b	0.6a
Ravaz index	2.3a	7.5a

[1] only parameters with 10 measurements are presented. For weight of 100 berries, grape sugar and acids contents only two measurements were done and this was considered as insufficient for conclusions.
[2] means followed by the same letter were not significantly different ($p \leq 0.05$).

4 CONCLUSIONS

The comparison of scion fertility described as number of bunches/vine showed that fertility of standard was placed between the fertilities of cl. 191 and 15. The scion fertility of inspected grafting combinations in the experiment was yearly dependent but ratios between the treatments were consistent in both years. The bunch weight of standard was significantly higher than those of French clones what was further demonstrated in the higher yield/vine in comparison to cl. 191 and very near of that for cl. 15 (ENTAV et al., 1995). Higher rainfall during the grape ripening lowered the differences in bunch weight and weight of 100 berries between the treatments. The above mentioned indicates that rootstocks more evidently influenced the yield properties in conditions of rainfall deficiency during the grape ripening. The grape quality of standard was lower than the grape quality of cl. 191 and higher than of cl. 15. Interestingly the standard material had the productivity near the level of cl. 15 and pruning weight near or equal to cl. 191 what means that very productive and also very vigorous vines were selected in the mass selection. Therefore Ravaz index for standard was almost one fold higher than for cl. 191 and more than one fold lower than for cl. 15. In the case of comparison between the standard and cl. 15 it should be noted that they were grafted onto a different rootstocks what also influenced the yield properties. The problem of lower grape quality of standard was not so evident in the exceptional year 2001 but it could be provoked in less favorable climatic conditions. Probably further (re)selection of standard material for cv. `Cabernet Sauvignon` is needed.

Although the differences in fertility, productivity and grape quality between cv. `Cabernet Sauvignon` standard grafted onto different rootstocks were not significant it was shown that `1103 Paulsen` rootstock, in comparison with `SO 4` and `420 A Mgt`, significantly increased the vegetative growth of scion. `SO 4` led to the highest bunch weight and quite high yield/vine of standard beside the lower pruning weight/vine. That resulted in slightly higher Ravaz index for that grafting combination. By contrast, `1103 Paulsen` demonstrated lower values of Ravaz index due to quite high yield/vine in both years beside significantly higher pruning weight/vine. These results are consistent with the results of Peterlunger et al. (1998) and the yield:pruning ratio was therefore strictly dependent on the rootstock which undoubtedly influenced biomass allocation between vegetative and reproductive parts

of the grapevine as was already shown (Ollat et al., 2003). The rootstocks inspected in the experiment had no significant influence on the grape quality of cv. `Cabernet Sauvignon` standard. In accord with the vine growing standards, `SO 4` and `420 A Mgt` should be considered as proper rootstock selection for standard material of cv. `Cabernet Sauvignon` in the lower part of the Vipava Valley. Possible enhancement of bunch stem necrosis has to be considered very carefully when cv. `Cabernet Sauvignon` is grafted onto `SO 4` (ENTAV et al., 1995). Beside the selection of mentioned rootstocks `1103 Paulsen` and `140 Ruggeri` also should be taken into account especially when the vineyards are planted on the location with repeated soil water deficiency. In the experimental vineyard the positive influence of `140 Ruggeri` rootstock on the grape quality was also proved beside its impact on vigorous growth of vines comparable to that of `1103 Paulsen` (data not shown).

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