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Productivity of 'Chambourcin' Grape, Own-Rooted and Grafted to Seven Different Rootstocks

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Abstract

The French-American interspecific hybrid grape cultivar 'Chambourcin' (26.205 Joannés-Seyve) was planted in 2004 at Mountain Grove, Mo., on seven different rootstocks (3309C, 101-14 Mgt, 5BB, SO4, 110R, 1103P, Freedom). Own-rooted 'Chambourcin' was also grown. The site characteristics are latitude 37° 9' N, longitude 92° 16' W, elevation 442 m, USDA plant hardiness zone 6a, and a Viraton silt loam soil with 2 to 5% slope. The soil is characterized as acidic, moderately well-drained, and slowly permeable with chert and fragipan in the subsoil. This soil restricts root growth, is prone to drought, and reduces vine vigor. Rootstocks were tested in a replicated trial during the years 2009 to 2013 to improve scion productivity. 'Chambourcin' grafted to 3309C, 5BB, and 1103P had significantly higher yield per vine compared to own-rooted. The remaining rootstocks were not significantly different from own-rooted. Vines grafted to 3309C and 1103P had significantly higher pruning weight per vine compared to own-rooted in three years. The remaining rootstocks were not significantly different from own-rooted. Average cluster and berry weights were not significantly affected by rootstocks in all years, but own-rooted vines were significantly lower in some years. Juice soluble solids was significantly higher for own-rooted compared to some rootstocks in two years, a likely result of lower yields on these vines. Juice titratable acidity was not affected by rootstock, and pH was affected one year. Crop load (yield to cane pruning weight ratio) ranged from 12 to 15. Lower crop loads would likely have improved fruit composition. Productivity of 'Chambourcin', a cultivar prone to low vigor when grown on a restrictive soil, can be improved when grafted to rootstocks. The rootstocks 3309C, 5BB, and 1103P appeared best.

'Chambourcin' is a high quality wine grape that is suitable for growing in Missouri. It is one of the best red grape cultivars grown in the state that is fermented to a dry, red wine and barrel aged to a premium product (Wilker, K., personal communication, July 30, 2015). 'Chambourcin' is moderately adapted to southern Missouri (USDA Hardiness zone 6a) as phloem, cambium, and buds are cold tender when average January temperature drops below -20 ˚C (Brusky-Odneal, 1983). Using differential thermal analysis, lethal temperature for 50% primary bud mortality of 'Chambourcin' was -22.9 ˚C (Gu et al., 1997). While classified as having good resistance to downy (*Plasmopara viticola* (Berk. & M.A. Curtis) Berl. & De Toni) and powdery (*Uncinular necator* (Schwein.) Burrill) mildews (Galet, 1998), it is susceptible to these fungal diseases under the moist, humid conditions that occur in the state. A season long spray program is required to control disease and insect pests. Clusters are rated as compact, voluminous, often with shot berries (Galet, 1998). In my experience, clusters tend to be loose, so they are not susceptible to bunch rot (*Botrytis cinerea* Pers.). Additionally, fruit set is variable depending on the year, so crop regulation beyond dormant balance pruning may be needed. Fruit matures in late Sept. through early Oct. in southern Missouri. The vine is rated as extremely vigorous with a spreading growth habit and susceptible to drought (Galet, 1998); however, in my experience this depends on the site where vines are grown. The southern half

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of Missouri is in the Ozark Plateau region. Many of the soil types are of fine texture and shallow depth due to the occurrence of a fragipan. The latter is a dense subsurface horizon that restricts water drainage and root penetration, and makes soils drought prone. In my experience, 'Chambourcin' is not vigorous when grown in a soil with fragipan.

Grape rootstocks are important to overcoming the debilitating effects of phylloxera (*Daktulosphaira vitifoliae* Fitch) and nematodes (*Pratylenchus, Xiphinema, Meloidogyne spp*.) in *Vitis vinifera* L. scions (Pongrácz, 1983). They are also used to improve vine adaptation to soil problems such as high pH, salt, and drought (Howell, 1987). Rootstock influence on scion vigor is another use. Possible mechanisms for a grape rootstock to influence scion vigor are alteration of the graft union to affect phloem and xylem transport or root system growth habit to affect rooting depth (Howell, 1987, Pongracz, 1983). The purpose of this study was to determine whether 'Chambourcin' vigor and productivity could be enhanced by grafting to grape rootstocks.

Materials and Methods

'Chambourcin' was planted in 2004 at Mountain Grove, MO. The site is at latitude 37° 9' N and longitude 92° 16' W with an elevation of 442 m. It is USDA plant hardiness zone 6a. The soil is a Viraton silt loam soil with 2 to 5% slope (Web Soil Survey). The soil is characterized as a naturally acidic (pH 4.5 to 6.0), silt loam topsoil and a very cherty, silty, clay loam subsoil with a fragipan at 45 to 85 cm depth. It is rated as moderately well-drained with a low water holding capacity because of its shallow depth. The long growing season (≥190 frost-free days) of this location allows enough time for 'Chambourcin' to mature.

'Chambourcin' was grafted to seven different rootstocks: 3309C, 101-14 Mgt, 5BB, SO4, 110R, 1103P, and Freedom. Own-rooted vines were also planted. Spacing was 2.4 m within and 3.0 m between rows. Experiment design was a randomized complete block with four replications. Vines were trained to a high, bilateral cordon with eight node bearing canes and two node renewal spurs. Balance pruning was used to regulate cropping at a level of 20 plus 10 nodes retained for each pound (0.454 kg) of dormant cane prunings. The vineyard was managed with no additional crop control (cluster thinning), so the decision was made to only use balance pruning to regulate cropping for the trial period. Vineyard floor was managed using pre and post emergent herbicides along trellis rows and permanent ground cover of tall fescue (*Festuca arundinacea* Shreb.) in row middles. Nitrogen was applied annually and gradually increased to 78 kg/ha of actual N by the end of the trial. Other macronutrients were brought-up to desired soil test maintenance levels (112 kg P, 224 kg K, 2244 kg Ca, and 450 kg Mg per ha) at the beginning of the trial. Soil was amended with lime to maintain pH above 6.0 over the test years. Vine productivity measurements were recorded from 2009 through 2013 and included yield per vine; cane pruning weight per vine; average cluster and berry weights; and juice soluble solids (%), pH and titratable acidity (g/L). ANOVA was performed on the raw data and means separated by Tukey-Kramer HSD (P=0.05)

Results and Discussion

The grape rootstocks used in this trial are of varying parentage. 3309C and 101-14 Mgt are *V. riparia* x *V. rupestris* crosses. SO4 and 5BB are *V. berlandieri* x *V. riparia* crosses. 110R and 1103P are *V. berlandieri* x *V. rupestris* crosses. The rootstocks 110R and 1103P are best adapted to fine texture, shallow, droughty soil (Galet, 1998; Howell, 1987; Pongrácz, 1983; Shaffer, 2002; Shaffer et al. 2004). These are the soil conditions that occur at Mountain Grove. Because the trial vineyard was amended with lime, rootstock tolerance to acidic soil was not as important.

Rootstock enhancement of scion vigor and tolerance to drought were desirable to investigate since they were needed on our site. These attributes vary among the rootstocks with *V. berlandieri* x *V. riparia* (SO4, 5BB) rated higher in scion vigor and *V. berlandieri* x *V. rupestris* (110R, 1103P) rated higher in tolerance to drought (Howell, 1987; Shaffer, 2002; Shaffer et al. 2004). While this implies *V. riparia* x *V. rupestris* crosses (3309C, 101-14 Mgt) are intermediate, both of these have desirable effects on either scion vigor (101-14 Mgt) or tolerance to drought (3309C) (Shaffer, 2002; Shaffer et al. 2004). Freedom rootstock is a 1613C x Dog Ridge hybrid that was included in this trial (Freedom, 2015). It is nematode resistant and promotes scion vigor, but lacks phylloxera and drought resistance (Howell, 1987). The vineyard site favored the use of a rootstock that adapted vines to shallow, droughty, soil and also enhanced scion vigor. Potentially any of the rootstocks could be acceptable.

Yield per vine was not significantly different among the seven different rootstocks, but own-rooted was significantly lower than grafted vines with the specific rootstocks varying by year (Table 1). This shows an advantage of grafted over own-rooted vines. 'Chambourcin' is not prone to phylloxera infestation (Galet, 1998). No foliar form of phylloxera was noted on own-rooted vines. Of the seven different rootstocks, 3309C, 5BB, SO4 and 1103P had the highest yields although these were not significantly different from the other three rootstocks. The rootstock 5BB significantly increased yield of 'Chardonel' over own-rooted vines in Arkansas (Main et al., 2002). In that same trial, 110R and Freedom also had higher yields than own-rooted vines but the difference was not significant. The vineyard location in Fayetteville, AR has similar soil characteristics to this vineyard. In this trial, grafted vines had excessive yields in some years (Table 1). Additional crop control by cluster thinning could have prevented this, but was not done. Balance pruning to 15 to 20 nodes per pound (0.454 kg) of cane prunings and thinning to 1 to 2 clusters per shoot optimized yield of 'Chambourcin' in southern Illinois (Kurtural et al., 2006). Of the rootstocks tested, 3309C,101-14 5BB and 1103P have some tendency to overbear (Shaffer, 2002; Shaffer et al. 2004). This occurred in 2010 and 2013 in the trial (Table 1).

Pruning weight is a measure of vine growth and is positively related to yield the following season (Partridge, 1925; Kimball and Shaulis, 1958). Vines with higher pruning weights are balance pruned to leave more nodes. These nodes have buds with shoot and cluster primordia for next season's crop. Significant differences occurred in three of the five test years (2009, 2011, 2012). Vines grafted to rootstocks 3309C, 101-14 and 1103P had higher pruning weights than own-rooted vines (Table 2). The other rootstocks were not different from own-rooted; however, the latter tended toward the lowest prun-

Table 1. Yield (kg) per vine of 'Chambourcin' grape, own-rooted and grafted to seven rootstocks, at Mountain Grove, MO, 2009-2013.

Rootstock	2009		2010		2011		2012		2013	
Own	4.42	bc[z]	8.24	bc	6.11	bc	5.58	bc	5.89	bc
3309C	13.63	a	20.75	a	11.98	a	10.93	a	15.68	a
101-14	8.98	ab	16.93	ab	7.24	ab	13.27	a	10.70	ab
5BB	13.34	a	17.27	a	7.26	ab	9.79	ab	12.84	ab
SO4	12.78	ab	16.48	ab	11.90	ab	10.63	ab	14.16	ab
110R	12.82	ab	13.38	ab	9.89	ab	10.13	ab	10.73	ab
1103P	10.91	ab	18.64	a	9.13	ab	12.37	a	17.00	a
Freedom	10.88	ab	17.31	a	10.14	ab	10.31	ab	10.93	ab

[z]Means in a column not followed by a common letter are significantly different by Tukey-Kramer HSD, $P \leq 0.05$.

Table 2. Cane pruning weight (g) per vine of 'Chambourcin' grape, own-rooted and grafted to seven rootstocks, at Mountain Grove, MO, 2009-2013.

Rootstock	2009		2010		2011		2012		2013	
Own	355	bc[z]	1535		462	bc	511	bc	205	
3309C	1084	a	1560		1089	a	1150	a	686	
101-14	1008	ab	1560		706	ab	1051	ab	566	
5BB	558	ab	1285		555	bc	869	ab	621	
SO4	852	ab	1138		824	ab	795	ab	364	
110R	634	ab	1562		838	ab	911	ab	391	
1103P	935	a	1587		930	a	1152	a	674	
Freedom	724	ab	1569		597	ab	795	ab	484	

[z]Means in a column not followed by a common letter are significantly different by Tukey-Kramer HSD, $P \leq 0.05$.

ing weight. Among the rootstocks in 2009, 2011 and 2012, there were no significant differences except for 5BB being lower than 3309C and 1103P in 2011. The implication is that grafted vines were more vigorous than own-rooted vines in this trial.

A desirable crop load (yield to cane pruning weight ratio) for *V. vinifera* L. is 10 to 12 as stated by Bravdo et al. (1984, 1985), but may be lower or higher than 10 for certain training systems and vine spacings (Kliewer and Dokoozlian, 2000; Reynolds et al., 1986; Reynolds and Wardle, 1994; Reynolds et al., 1995). In the long (195 day) growing season area of southern Illinois, own-rooted 'Chambourcin' grown at wide (2.4 m) spacing could have crop loads of 10 to 14 (Dami et al., 2005). Growing season length and vine spacing used in southern Missouri are similar to southern Illinois. In contrast own-rooted 'Chambourcin' grown in a short (160 day) growing season area of northeast Ohio and at narrow (1.2 m) spacing required a crop load below 8 (Dami et al., 2005). They stated that variation in crop load between regions was due to length of growing season and vine spacing. A level of 15 to 20 nodes per pound (0.454 kg) of cane prunings was recommended for own-rooted 'Chambourcin' in a long growing season area of southern Illinois if follow-up cluster thinning of 1 to 2 per shoot was done (Kurtural et al., 2006). They stated that this balanced the vine with a yield of just under 10 kg, and provided optimum fruit composition and cane pruning weight (≥ 0.72 kg). In the present trial, an average crop load for all grafted vines varied between 12 and 15 over the first four years (data not shown). Own-rooted vines also had crop loads in this range, except in 2010 when it was 5. In 2013, crop load averaged almost 25 for all grafted vines (data not shown). Based on the work of Dami et al. (2005), vines in the first four years of the current trial were reasonably balanced, but were overcropped the last year.

Average cluster weight was influenced by rootstock in two of the five test years (2011, 2012) (Table 3). No differences occurred among the seven different rootstocks in either year. Own-rooted vines had significantly lower average cluster weight than vines on SO4 and 110R in 2011, and 101-14 Mgt and 1103P in 2012. Own-rooted vines tended to have lower average cluster weight than the other rootstocks in these years, but were not significantly different. Hybrid grapes including 'Chambourcin' have high bud fruitfulness and larger clusters compared to *V. vinifera* L. (Pool, et al., 1978; Reynolds, 1986). To obtain a crop load of 10 or less on grafted 'Chambourcin', cluster thinning to 10 per vine was needed in a short (160 day) growing season area of northeastern Ohio (Dami et al., 2006). This thinning level decreased yield and increased average cluster and berry weights. Less thinning led to higher crop load and yield, and lower

Table 3. Average cluster weight (g) of 'Chambourcin' grape, own-rooted and grafted to seven rootstocks, at Mountain Grove, MO, 2009-2013.

Rootstock	2009	2010	2011		2012		2013
Own	255	222	191	bc[z]	207	bc	152
3309C	265	305	264	ab	278	ab	214
101-14	275	306	244	ab	321	a	239
5BB	270	302	232	ab	295	ab	211
SO4	270	300	301	a	290	ab	209
110R	260	278	292	a	250	ab	186
1103P	255	292	237	ab	321	a	211
Freedom	260	292	233	ab	312	ab	211

[z]Means in a column not followed by a common letter are significantly different by Tukey-Kramer HSD, $P \leq 0.05$.

Table 4. Average berry weight (g) of 'Chambourcin' grape, own-rooted and grafted to seven rootstocks, at Mountain Grove, MO, 2009-2013.

Rootstock	2009	2010		2011		2012	2013	
Own	2.15	2.05	bc[z]	2.16	bc	1.98	2.16	bc
3309C	2.22	2.31	a	2.48	a	2.16	2.49	a
101-14	2.28	2.32	a	2.45	a	2.29	2.55	a
5BB	2.28	2.17	ab	2.34	ab	2.13	2.42	ab
SO4	2.35	2.28	a	2.51	a	2.18	2.47	a
110R	2.29	2.30	ab	2.40	ab	2.05	2.44	ab
1103P	2.32	2.32	a	2.49	a	2.20	2.53	a
Freedom	2.27	2.38	a	2.45	ab	1.99	2.44	ab

[z]Means in a column not followed by a common letter are significantly different by Tukey-Kramer HSD, $P \leq 0.05$.

average cluster and berry weights (Dami et al., 2006).

Average berry weight was different in three of the five test years (2010, 2011, 2013) (Table 4). Much like average cluster weight, no differences occurred among the seven different rootstocks in these three years. Own-rooted vines had significantly lower average berry weight than vines on 3309C, 101-14 Mgt, 1103P and Freedom in 2010; 3309C and 1103P in 2011; and 3309C, SO4, 101-14 Mgt, and 1103P in 2013. The rootstocks 3309C and 1103P tended to have higher average berry weight in these three years. This did not result in higher average cluster weight for these rootstocks in 2011 (Table 3). Both average cluster and berry weights had significant differences only in 2011. Own-rooted vines tended to have lowest values for both average cluster and berry weights when compared to grafted vines. Cluster weight is determined by the number of berries set and berry weight. A reduction in either of these will result in lower cluster weight. It is likely that own-rooted vines also had a lower berry set, but this was not verified in this trial since number of berries per cluster was not recorded.

Juice soluble solids (SS) were significantly different in 2010 and 2013 (Table 5). An assumption is that soluble solids accumulation and yield per vine are negatively related. Cluster thinning of 'Chambourcin' increased soluble solids linearly as crop levels were reduced (Dami et al., 2005 and 2006; Kurtural et al., 2006). In this trial, own-rooted vines had significantly higher soluble solids than vines grafted to 101-14 Mgt and 5BB in 2010, and 3309C and 1103P in 2013. This was a likely result of the lower yields on own-

Table 5. Juice soluble solids (%) of 'Chambourcin' grape, own-rooted and grafted to seven rootstocks, at Mountain Grove, MO, 2009-2013.

Rootstock	2009	2010		2011	2012	2013	
Own	21.60	22.75	a[z]	23.65	23.18	22.90	a
3309C	21.23	21.70	ab	22.50	22.83	21.45	bc
101-14	21.80	20.75	bc	21.90	23.00	22.10	ab
5BB	22.15	20.58	bc	22.80	22.95	22.15	ab
SO4	21.50	21.80	ab	21.95	22.50	22.35	ab
110R	21.80	22.00	ab	23.00	22.70	22.85	ab
1103P	20.90	21.73	ab	22.03	22.55	21.48	bc
Freedom	21.85	21.75	ab	23.30	22.30	22.20	ab

[z]Means in a column not followed by a common letter are significantly different by Tukey-Kramer HSD, $P \leq 0.05$.

Table 6. Juice pH of 'Chambourcin' grape, own-rooted and grafted to seven rootstocks, at Mountain Grove, MO, 2009-2013

Rootstock	2009	2010		2011	2012	2013
Own	3.41	3.38	ab[z]	3.46	3.43	3.20
3309C	3.39	3.44	ab	3.47	3.45	3.26
101-14	3.46	3.44	ab	3.49	3.50	3.28
5BB	3.33	3.33	bc	3.42	3.40	3.21
SO4	3.41	3.39	ab	3.48	3.40	3.24
110R	3.45	3.44	ab	3.44	3.40	3.23
1103P	3.41	3.50	a	3.55	3.55	3.27
Freedom	3.43	3.46	ab	3.51	3.45	3.30

[z]Means in a column not followed by a common letter are significantly different by Tukey-Kramer HSD, $P \leq 0.05$.

rooted vines. These differences were small, about 1%, and not important from a practical winemaking standpoint. The increase in soluble solids would not offset the economic loss from lower yields on own-rooted vines.

Juice pH was significantly different only in 2010 (Table 6). Vines grafted to 1103P and 5BB had highest and lowest pH, respectively. Lower pH values could be important in winemaking but it was not consistent for 5BB across the years of the trial. For juice pH, own-rooted vines were not different from grafted even with their lower yields. In general, pH values in all years except 2013 were high for winemaking. It was a likely result of delaying fruit harvest to obtain lower titratable acidity (TA) values.

Juice titratable acidity was not influenced by rootstock (Table 7). Rootstocks rarely influenced pH and titratable acidity of 'Chardonel' own-rooted and grafted (Freedom, 5BB, 110R) vines (Main et al., 2002). Cluster thinning 'Chambourcin' vines resulted in very few pH and titratable acidity differences (Dami et al., 2005 and 2006; Kurtural et al., 2006). Based on these research reports, juice pH and titratable acidity appear to be insensitive to use of rootstock and cluster thinning. The high yields on grafted vines in some years of this trial resulted in less balanced SS, pH, and TA during fruit ripening that required delaying harvest. More balanced fruit composition and earlier ripening could be obtained by reducing crop load through greater pruning severity, cluster thinning or a combination of both.

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Table 7. Juice titratable acidity (g/L) of 'Chambourcin' grape, own-rooted and grafted to seven rootstocks, at Mountain Grove, MO, 2009-2013.

Rootstock	2009	2010	2011	2012	2013
Own	0.92	0.75	0.70	0.67	0.86
3309C	0.91	0.75	0.79	0.71	0.97
101-14	0.85	0.74	0.80	0.67	0.92
5BB	0.88	0.82	0.80	0.72	0.93
SO4	0.94	0.78	0.75	0.67	0.83
110R	0.94	0.71	0.76	0.67	0.86
1103P	0.95	0.72	0.82	0.60	0.97
Freedom	0.85	0.73	0.74	0.69	0.93

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