

## Effect of Precocious Grapevine Fruiting on Subsequent Year's Growth and Yield

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**Additional index words:** interspecific hybrid, overcropping, Ravaz index, vine vigor

### Abstract

Vineyard managers are often advised to remove reproductive growth components of vines in the first two years of growth to better establish the root system. In general, this is good advice as it will lead to a stronger vine; yet, there is a lack of research information on the effects of producing an early harvest on vigorous vines. Two locations (Oklahoma and Mississippi) were used to evaluate three wine grape cultivars at each location for fruiting in the second year of growth with subsequent effect on third year vegetative growth and reproductive yields. Reproductive component removal treatments had little effect on fruit yield components. In Oklahoma, there were no differences in caliper in the first two data measurements during the year of treatment. In the following year, vines that were allowed to go to harvest were smaller than the vines that had inflorescences removed in the previous year. Similar results for pruning weights were seen in Mississippi with the veraison (color change) and harvest treatments weighing less than the inflorescence removal treatment. The Ravaz index indicated that all cultivars in Oklahoma ('Cynthiana', 'Rubaiyat', 'Traminette') were within the recommended range of 5-10. In Mississippi, 'Blanc Du Bois' was slightly below the recommended range, indicating that the vines could have supported a heavier crop, whereas 'Villard blanc' was near the upper limit indicating that it was probably overcropped. 'MissBlanc' was in the acceptable range. These results suggest that vineyard managers can allow vigorous, well-managed, fully-trained vines to fruit in the second year without causing irreparable damage. The caveat is in marginally adapted and/or less vigorous cultivars, where lack of cold hardiness, disease susceptibility, or overcropping may lead to dieback or loss of vigor, as was seen in 'Villard blanc'.

Both Mississippi and Oklahoma have relatively small grape industries, therefore room for expansion exists. Neither state is considered a prime growing region for bunch grapes (*Vitis* spp.), yet they can be grown successfully with the proper site, cultivar selection, and cultural management. In fact, considerable research on bunch grapes has been conducted in both states for over a century (Stafne, 2006, 2016a) that has provided a solid base of information for possible industry growth. Currently, nearly all grape growers in these two states have small-scale vineyards. Thus, justifying the expense of

infrastructure, labor, equipment, and plant material is a critical decision.

Establishment of a vineyard is a capital intensive endeavor. Cost estimates range from \$17,290 to \$49,400 per ha based on many factors and the break-even point may not be achieved within a decade or even longer (Poling and Spayd, 2015). Therefore, early vine production would help to begin the process of recouping start-up costs faster. One option is to train vines to the trellis system in the first year to support fruit in the second year. In some areas, and for some cultivars, this is not possible due to difficult growing

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This publication is a contribution of the Mississippi Agricultural and Forestry Experiment Station. We thank Wayne Adams, Ned Edwards, Mark Henderson, David Lee, William McGlynn, Richelle Stafne, and Lavonne Stringer for their assistance in the completion of this study. We also thank T. Casey Barickman and Rick Snyder for their editorial reviews.

conditions or lack of vine vigor. However, in regions with long, hot growing seasons and vigorously growing cultivars, vine establishment is not difficult.

Often vineyard managers are advised to remove reproductive growth components (flowers and clusters) in the first two years of growth to better establish the vine root system, or to retain a very few clusters. This helps to prepare the vine for the stress of producing a crop in its third year (Dami et al., 2005; Poling and Spayd, 2015; Zabadal, 1997). Intrinsically this should lead to a stronger vine and root system, yet there is little information concerning early cropping on vigorous vines that may have the capacity to carry a sizeable crop. Zabadal (1997) stated that cropping in year three could be 4 t/ac (9.8 t/ha) with large vine size or even up to 7 t/ac (17.3 kg/ha) for 'Niagara' (*V. labruscana*) in non-limiting growth conditions with proper cultural management. However, the research results demonstrate that large crop loads may not adequately mature or could reduce vine size. Vines that are overly vigorous can benefit from a governing of their growth (Costello, 2010; Dami et al., 2005) because vines that grow too fast may produce weak wood that may be cold sensitive, break easily, and/or produce poor quality fruit in the subsequent year. One way to mitigate this issue is to allow vines to produce fruit to reduce rank vegetative growth.

Previous research has examined the effect of crop thinning on fruit quality and vine growth (Ames et al., 2016; Ferree et al., 2003; Keller et al., 2005; King et al., 2015). However, these techniques are usually applied on mature vines and not those that are newly established. Complete removal of vine reproductive components is also not done, but rather targeted thinning of blooms and/or clusters to achieve a particular desired crop load. Dami et al. (2005) recommended removing all flowers and fruit prior to 30 cm of growth in the first and second growing seasons unless vines were very vigorous, but even then only one or two clusters per vine

maximum should be allowed. Much of the information on crop control of vines comes from regions that grow different cultivars in different environments than the southern United States; thus, there is a need to test the effects of crop control in non-traditional, but expanding, grape growing regions.

The purpose of this study was to determine the effect of full crop loads in the second year on six wine grape cultivars of varying vigor and capacity in two southern locations with long growing seasons. The hypothesis was that vines completely trained to the trellis system in the first year will fruit in the second year and will not induce evidence of damage or injury in the subsequent (third) year.

### Material and Methods

Two locations were used for this study. The first location was at the Cimarron Valley Research Station, Perkins, OK (35.97° N lat., 97.03° W long). The soil was Konawa loamy fine sand with Teller fine sandy loam intrusions. At this location, 3 interspecific hybrid cultivars were used: 'Cynthiana', 'Rubaiyat', and 'Traminette'. 'Cynthiana' and 'Rubaiyat' vines were not grafted to a rootstock while 'Traminette' was grafted to 101-14 Mgt rootstock. Vines were planted in spring 2009. Plants were spaced 2.4 m apart in-row with a between-row spacing of 3.7 m on a high cordon trellis system 1.8 m high. Four treatments were applied in 2010 at targeted growth stages based on Eichorn and Lorenz (1977): removal of inflorescences, EL 17; removal of clusters at bb-sized berry stage, EL 29; removal of clusters at beginning of veraison, EL 35; and, full harvest, EL 38. Inflorescences and clusters were removed and counted. Cluster weights and berry weights were from an average of 10 clusters and 20 berries per vine, respectively. All vines were allowed to fully fruit without crop load modification in 2011. The experimental design was a completely randomized design with four treatments and three replications per treatment with two replicate vines per treatment. Maintenance practices recommended

by Oklahoma State University Cooperative Extension Service were followed throughout the growing season (Stafne, 2010), with regular irrigation and fungicide applications. Vines were spur pruned in early to mid-March and fresh pruning weights were taken in the field with a Rapala digital scale (Normark Corporation, Minnetonka, Minn.). Approximately 40 to 50 nodes were left on each vine after pruning. Grape vine trunk diameter was measured at 30 cm above the soil line with a Mitutoyo Absolute Digimatic (Mitutoyo Corp., Kawasaki, Japan). Sugar concentration (SSC) was measured using a Digital Pocket Refractometer ATAGO PAL-1 (Atago Co., Ltd., Tokyo, Japan).

The second site was located at the United States Department of Agriculture-Agriculture Research Service, Thad Cochran Southern Horticultural Laboratory, Poplarville, MS (30.84°N lat., 89.53°W long.). The soil was Ruston fine sandy loam. At this location, 3 cultivars were used: 'Blanc Du Bois', 'Miss-Blanc', and 'Villard blanc'. Vine spacing was 2.1 m x 3 m on a high cordon trellis system at 1.8 m. Vines were planted in spring 2013, three treatments (removal of inflorescences EL, 17; removal of clusters at beginning of veraison, EL 35; full harvest, EL 38) were applied in 2014. Cluster weights and berry weights were from an average of 10 clusters and 20 berries per vine, respectively. All vines were allowed to fully fruit without crop load modification in 2015. Vines were drip irrigated and cultural management, including fungicide sprays, followed recommended practices for Mississippi (Stafne, 2016b).

The experimental design was a randomized complete block with six blocks, three treatments and three sample vines per treatment in each block. Vines were spur pruned in late February and early March and fresh pruning weights were taken on an Ohaus Explorer Pro model EP12001 balance scale (Ohaus Corp., Pine Brook, NJ). Approximately 40 to 60 nodes were left on each vine after pruning. Trunk diameter was measured at 30 cm above the soil line with a Mitutoyo Absolute Digimatic (Mitutoyo Corp., Kawasaki, Japan). Sugar concentration was measured in °Brix using a Reichert (Leica) AR200 Digital Refractometer (Reichert, Inc., Depew, NY). Data were analyzed by two-way analysis of variance ( $P \leq 0.05$ ) using the FIT MODEL procedure in JMP 12.2 (SAS Institute, Cary, NC, USA) with cultivar and treatment as main effects and cultivar\*treatment as the interaction. Main effect means were separated by Tukey's HSD ( $P \leq 0.05$ ) where the interaction was non-significant. Due to differences in location, time, and cultivar, location were analyzed separately and not compared.

## Results and Discussion

'Blanc Du Bois' had more inflorescences than 'MissBlanc' and 'Villard blanc'. The total number of clusters removed was not significantly different; however, 'Blanc Du Bois' had almost twice as many as 'Miss-Blanc' and 2.5 times as many as 'Villard blanc' (Table 1). 'Blanc Du Bois' is known to have a vigorous growth habit (Mortensen, 1987) and to be highly productive. 'Miss-Blanc' was reported to have excellent vine

**Table 1.** Reproductive component removal treatments on three interspecific hybrid grape cultivars in second year of growth (2014) in Mississippi.

Cultivar	Inflorescences Removed (no.)	Clusters Removed (no.)	Cluster Weight (g)	Berry Weight (g)
Blanc Du Bois	79.8 a <sup>z</sup>	38.4 <sup>y</sup>	41.0 b	1.78
MissBlanc	17.3 b	20.0	27.6 b	1.52
Villard blanc	17.3 b	15.2	57.9 a	1.50

<sup>z</sup> Means within a column not followed by the same letter are significantly different as determined by Tukey's HSD ( $P < 0.05$ ).

<sup>y</sup> Means within columns without letters are not significantly different.

**Table 2.** Second year yield components of six interspecific hybrid grape cultivars at two locations, Oklahoma (2010) and Mississippi (2014).

Cultivar	Berry Weight (g)	Cluster Weight (g)	Harvested Clusters (no.)	Soluble Solids Conc. (%)	Yield (kg·vine <sup>-1</sup> )
Oklahoma					
Cynthiana	1.08 c <sup>z</sup>	35.8 b	20.8 <sup>y</sup>	18.6 c	0.6 b
Rubaiyat	1.84 a	18.4 b	29.7	19.5 b	0.8 b
Traminette	1.47 b	95.2 a	39.7	20.9 a	3.2 a
Mississippi					
Blanc Du Bois	3.04 a	65.5 a	42.4 a	18.0 a	3.1 a
MissBlanc	2.27 b	29.2 b	13.7 b	15.9 b	0.4 b
Villard blanc	2.46 b	71.1 a	24.5 ab	16.1 b	1.2 b

<sup>z</sup> Means within a column and location not followed by the same letter are significantly different as determined by Tukey's HSD ( $P \leq 0.05$ ).

<sup>y</sup> Means within columns without letters are not significantly different.

vigor when released (Overcash et al., 1982) is able to produce up to 20 kg per mature vine. 'Villard blanc' has more moderate vigor, but well established vines can be very productive (Clark, 1997). 'Villard blanc' had the highest mean cluster weight at almost 58 g (Table 1). Mean berry weight did not differ among the cultivars in Mississippi in the second year. These data were not collected in Oklahoma.

There were significant difference in berry and cluster weights, SSC, and yield in the Oklahoma grape cultivars. In Mississippi, significant differences were observed among the cultivars for all yield components (Table 2). Trunk diameter was smallest for 'Cynthiana' at the beginning of 2010, but 'Traminette' was the largest in fall of 2010 and 2011 (Table 3) in Oklahoma. Pruning weight was highest for 'Traminette' in spring 2011. By the end of the subsequent year vines that were allowed to go to harvest were significantly smaller than vines that had inflorescences removed (Table 3). One concern about early cropping is potential impairment of the root system growth (Poling and Spayd, 2015). In studies of other plants, trunk diameter was positively correlated with root growth (Pool et al., 2012; Drexhage and Gruber, 1999), although this may only relate to structural roots rather than fine roots (Am-

mer and Wagner, 2005). Lakso and Eissenstat (2012) reported that once 'Concord' vines were cropped only 10 to 20% of growth went to production of new roots. In addition, heavy crop loads may reduce medium-sized roots but not fine roots. The smaller trunk diameter in the harvest treatment when compared to the inflorescence removal treatment indicates that the root system could be likewise affected. However, none of the cultivars tested in this study had suppressed trunk growth from year two to year three (Table 3, 4).

In Oklahoma, fresh pruning weights were highest when inflorescences or EL 29-stage clusters were removed (Table 3). Pruning weight results were similar in Mississippi with the veraison and harvest treatments having less weight than the inflorescence removal treatment (Table 4). Vegetative measurements were not affected by cluster thinning treatments on 'Blanc Du Bois' (Ames et al., 2016), something also noted by Ferree et al. (2003) on 'Vidal blanc' and 'Chardonnay'. In this study there was a significant cultivar\*removal interaction at both locations; yet, these interactions were not extremely informative, largely following the main effect results. The following year (2016) results in Mississippi revealed no differences among treatments for prun-

**Table 3.** Trunk diameter and pruning weights of three interspecific hybrid grape cultivars and four reproductive component removal timings in Oklahoma.

Treatment	Trunk diameter			Pruning weight
	Sp 2010 (mm)	Fall 2010 (mm)	Fall 2011 (mm)	Sp 2011 (kg•vine <sup>-1</sup> )
<b>Cultivar</b>				
Cynthiana	8.2 b <sup>z</sup>	17.4 b	22.8 c	0.63 b
Rubaiyat	9.6 a	18.7 b	25.4 b	0.52 b
Traminette	9.4 a	23.2 a	29.7 a	1.00 a
<b>Removal Timing</b>				
Inflorescence (EL 17)	9.1 <sup>y</sup>	20.6	27.7 a	0.97 a
BB-sized (EL 29)	9.3	20.3	26.5 ab	0.85 a
Veraison (EL 35)	9.2	19.1	25.1 ab	0.53 b
None (EL 38)	8.6	19.0	24.6 b	0.51 b
<b>Significance (P-value)</b>				
Cultivar	0.0035	0.0001	0.0001	0.0001
Removal	0.5892	0.0784	0.0309	0.0001
Cultivar*Removal	0.9075	0.0219	0.1455	0.0001

<sup>z</sup> Means within a column and category not followed by the same letter are significantly different as determined by Tukey's HSD (P<0.05).

<sup>y</sup> Means within columns without letters are not significantly different.

**Table 4.** Trunk diameter and pruning weights of three wine grape cultivars and three reproductive component removal timings in Mississippi.

Treatment	Trunk diameter			Pruning Weight	Pruning Weight
	Sp 2014 (mm)	Fall 2014 (mm)	Fall 2015 (mm)	Sp 2015 (kg•vine <sup>-1</sup> )	Sp 2016 (kg•vine <sup>-1</sup> )
<b>Cultivar</b>					
Blanc Du Bois	9.3	22.9 a	28.6 a <sup>z</sup>	1.09 a	2.49 a
MissBlanc	9.1	19.2 b	27.5 a	0.36 b	1.56 b
Villard blanc	8.8	18.7 b	24.3 b	0.51 b	0.71 c
<b>Removal Timing</b>					
Inflorescence (EL 17)	9.3 <sup>y</sup>	21.6	28.3	0.84 a	1.79
Veraison (EL 35)	8.9	19.8	25.7	0.61 b	1.51
None (EL 38)	9.1	19.3	26.4	0.50 b	1.46
<b>Significance (P-value)</b>					
Cultivar	0.3527	0.0002	0.0023	0.0001	0.0001
Removal	0.5258	0.0610	0.0873	0.0026	0.3304
Cultivar*Removal	0.4973	0.4858	0.8156	0.0163	0.5645

<sup>z</sup> Means within a column and category not followed by the same letter are significantly different as determined by Tukey's HSD (P<0.05).

<sup>y</sup> Means within columns without letters are not significantly different.

ing weight. In Oklahoma, no difference were observed in fruit yield components from the applied treatments (Table 5). Removal treat-

ments had little effect on fruit yield components aside from third-year mean cluster weight in Mississippi, where removal of

**Table 5.** Third year (2011) yield components of three wine grape cultivars and four reproductive component removal timings in Oklahoma.

Treatment	Berry Weight (g)	Cluster Weight (g)	Yield (kg•vine <sup>-1</sup> )	Ravaz Index (kg•kg)	Soluble Solids Conc. (%)
<b>Cultivar</b>					
Cynthiana	0.48 b <sup>z</sup>	28.1 c	3.0 b	5.31 b	18.0 a
Rubaiyat	1.35 a	54.7 b	3.1 b	7.20 ab	18.7 a
Traminette	1.27 a	77.1 a	6.7 a	8.17 a	16.2 b
<b>Removal Timing</b>					
Inflorescence (EL 17)	1.06 <sup>y</sup>	53.2	4.1	4.14 b	18.0 a
BB-sized (EL 29)	1.02	55.3	4.7	5.75 b	16.5 b
Veraison (EL 35)	1.07	54.9	4.4	8.84 a	18.1 a
None (EL 38)	0.99	49.8	3.9	8.83 a	18.0 a
<b>Significance (P-value)</b>					
Cultivar	0.0001	0.0001	0.0001	0.0001	0.0080
Removal	0.2136	0.5548	0.3419	0.0117	0.0001
Cultivar*Removal	0.1440	0.4073	0.4019	0.1622	0.5059

<sup>z</sup> Means within a column and category not followed by the same letter are significantly different as determined by Tukey's HSD ( $P \leq 0.05$ ).

<sup>y</sup> Means within columns without letters are not significantly different.

**Table 6.** Third year (2015) yield components of three wine grape cultivars and three reproductive component removal timings in Mississippi.

Treatment	Berry Weight (g)	Cluster Weight (g)	Yield (kg•vine <sup>-1</sup> )	Ravaz Index (kg•kg)	Soluble Solids Conc. (%)
<b>Cultivar</b>					
Blanc Du Bois	3.07	151.6	11.1 a <sup>z</sup>	4.97 b	17.8 a
MissBlanc	2.59	151.8	8.3 b	5.66 b	15.8 b
Villard blanc	3.00	132.5	5.3 c	9.75 a	16.2 b
<b>Removal Timing</b>					
Inflorescence (EL 17)	2.91 <sup>y</sup>	163.0 a	9.5	6.42	16.9
Veraison (EL 35)	2.91	139.5 ab	7.7	6.50	16.4
None (EL 38)	2.84	133.4 b	7.3	7.47	16.5
<b>Significance (P-value)</b>					
Cultivar	0.0007	0.1956	0.0001	0.0007	0.0001
Removal	0.8057	0.0400	0.1270	0.6421	0.3072
Cultivar*Removal	0.8216	0.6680	0.6887	0.3736	0.8889

<sup>z</sup> Means within a column and category not followed by the same letter are significantly different as determined by Tukey's HSD ( $P \leq 0.05$ ).

<sup>y</sup> Means within columns without letters are not significantly different.

inflorescences led to higher cluster weights than removal at veraison or the control (no removal) (Table 6).

While most of the cultivars used were well-adapted to the local climate, both 'Tra-

minette' and 'Villard blanc' are more marginally adapted for different reasons. 'Traminette' was susceptible to damage from low temperatures in New York, and 'Traminette' in Oklahoma is not as cold hardy as 'Cynthi-

ana' or 'Rubaiyat' (Reisch et al., 1996; E.T. Stafne, personal observation). 'Villard blanc' in Mississippi is tolerant of Pierce's disease (PD) (*Xylella fastidiosa* subsp. *fastidiosa* Wells et al.), but not as resistant as 'Blanc Du Bois' and 'MissBlanc', and can succumb to the disease after a decade or so (Hegwood, Jr., 1987). During this study, 'Villard blanc' exhibited terminal die-back of cordons that was not observed in the other two cultivars. Although diagnostically unconfirmed, this could be related to PD or another stress issue such as overcropping in the second year. Evidence could be seen in relatively poor increase of second year pruning weights as they grew only 39% compared to 128% for 'Blanc Du Bois' and 333% for 'MissBlanc' (Table 4).

The Ravaz index (Ravaz, 1903), the balance between reproductive growth (fruit yield) and vegetative growth (pruning weight), indicated that all cultivars in Oklahoma were within the recommended range of 5-10 (Smart and Robinson, 1991). 'Traminette' was significantly higher than 'Cynthiana', which was on the lower end of the acceptable range (Table 5). Rootstocks can play a role in above-ground response as well (Smart et al., 2006) and this could be the case with 'Traminette'. 'Cynthiana' is a low yielding cultivar, but was on par with 'Rubaiyat' in this study. In Oklahoma, 'Cynthiana' can be a slow grower in the first few years before becoming more vigorous around year five and beyond (E.T. Stafne, personal observation). In Mississippi, 'Blanc Du Bois' was slightly below the recommended Ravaz index range, indicating that the vines could have supported a heavier crop than was harvested (Table 6). Since 'Blanc Du Bois' was very vigorous with a high capacity for fruit production, it should be closer to the high end of the Ravaz index range. On the other hand, 'Villard blanc' was near the upper limit indicating that it may have been overcropped, a conclusion that is supported by the small pruning weight increase and winter dieback.

Removal treatment significantly affected

Ravaz index in Oklahoma (Table 5) but not Mississippi (Table 6). Early removal of reproductive components at stages EL 17 (4.14) and EL 29 (5.75) were significantly less than those at EL 35 (8.84) and EL 38 (8.83). The removal at the inflorescence stage led to undercropped vines, whereas the other treatments were within the recommended range of 5 to 10. All treatments in Mississippi resulted in Ravaz indices between 5 and 10.

### Conclusions

Overall, the vine reproductive component treatments affected vines in the year of treatment. However, in the subsequent year, except for 'Villard blanc', most vines continued to grow normally after allowing a full harvest in the second year. This suggests that vineyard managers can allow vigorous, well-managed, fully-trained vines to fruit in the second year without causing irreparable damage. The caveat to this is in marginally adapted and/or less vigorous cultivars, where lack of cold hardiness, disease susceptibility, or overcropping may lead to dieback or loss of vigor. Soluble solids levels obtained in the second year were acceptable for wine making, but other parameters such as anthocyanins and phenolics were not measured so the overall physiological maturity of the fruit may or may not be at desirable levels. Grapevine breeders can also use the results of this study to understand how precocious fruiting can be useful in developing new cultivars. The southern U.S. is in dire need of new PD-resistant bunch grape cultivars for commercial markets (Stafne, Sleezer, and Clark, 2015) and cultivars that satisfactorily bear an early crop can assist growers in recouping the upfront costs of production.

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