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Research Article

Impact of training system on ‘Blanc Du Bois’ vegetative growth, yield components and fruit composition

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Abstract

‘Blanc Du Bois’ (*Vitis* spp.) is the most widely grown Pierce’s disease tolerant white grapevine cultivar in Texas. As an interspecific hybrid, its growth habit is seimi-drooping, and 'Blanc Du Bois' is characterized as vigorous. This study evaluated the impact of training system (Mid-Wire Cordon with VSP, Mid-Wire Cane with VSP and Smart-Dyson, High-Wire Quadralateral, and Watson) on 'Blanc Du Bois' growth, yield components, and fruit composition at two locations in Texas. The first site was located in the Rio Grande Valley where the mean extreme minimum winter temperature is -1.1 to 1.7° C (USDA Cold Hardiness Zone 10a). As a result of climate and site conditions, vine size, determined by dormant pruning weight, was very large averaging from 3.71 to 5.56 kg per vine across training systems over a three-year period. At this site, the horizontally divided systems, High-Wire Quadrilateral and Watson were the highest yielding averaging 10.66 and 7.49 kg per vine, respectively, as a result of more shoots per vine, and higher fruitfulness. The Mid-Wire Cordon and Mid-Wire Cane Pruned Training Systems had lower yields in two out of three years, but fruit maturity indices soluble solids and pH reflected more advanced maturity at harvest. At the second site, located in the Central Gulf Coast of Texas (USDA Cold Hardiness Zone 8b), vines were less vigorous with pruning weights averaging 1.66 to

1.83 kg per vine across training systems over three years. Consistent differences in yield components, vine size, and fruit composition were not observed, and all the three training systems under study had acceptable growth and fruiting characteristics. The results of this research suggest that 'Blanc Du Bois' vigor potential and growth habit makes it well-suited for horizontally divided canopy training systems, particularly on vigorous sites.

Keywords

'Blanc Du Bois', training system, Watson Training System, High-Wire Quadrilateral, horizontally divided training system

Introduction

'Blanc Du Bois' is a Pierce's disease (PD) tolerant, interspecific hybrid wine grape cultivar released from the University of Florida in 1987 (Mortensen 1987). Since then, 'Blanc Du Bois' has become the leading PD tolerant white wine grape in Texas, and the fifth leading cultivar by acreage in the state (United States Department of Agriculture National Statistical Service 2019). 'Blanc Du Bois' wines are characterized by aromatics reminiscent of tropical and tree fruit, citrus, greenwood/grassy (Dreyer et al. 2012), and spicy (Mortensen 1987) flavors. High quality 'Blanc Du Bois' wines have been associated with higher concentrations of esters (Dreyer et al. 2012) and a wide range of wine styles are produced in Texas.

Mortensen (1987) described the growth habit of 'Blanc Du Bois' as vigorous and semi-drooping, which can present challenges, particularly in humid climates, in maintaining a favorable canopy microclimate. Canopy microclimate can influence yield, fruit composition (Dokoozlian and Kliewer 1995Smart and Sinclair 1976Smart 1987, Downey et al. 2005), and incidence of fungal diseases (Austin and Wilcox 2011, Austin et al. 2011). Ames et al. (2016) utilized shoot and cluster thinning as a means to optimize vine balance in 'Blanc Du Bois' and reported that thinning non-count shoots at the stages 12-15 by the modified Eichorn-Lorenz scale (Coombe 1995) decreased leaf area and increased light penetration in the canopy. However the vines under study were pruned to 40 buds per meter of canopy (Ames et al. 2016), a relatively high shoot density for a single canopy training system (Smart and Robinson. 1991). Divided canopy training systems were created to facilitate greater shoot numbers at lower shoot densities than single canopy training systems. As a result of the inverse relationship between shoot vigor and shoot number (Winkler et al. 1974), divided canopy training systems can improve the balance and canopy microclimate of vigorous vines leading to higher yields and node fruitfulness, and improved fruit composition (Reynolds and Heuvel 2009Smart et al. 1985a, Smart et al. 1985b). The objective of this research was to evaluate the impact of single canopy and divided canopy training systems (Mid-Wire Cordon with VSP, Mid-Wire Cane with VSP and Smart-Dyson, High-Wire Quadralateral, and Watson) on 'Blanc Du Bois' shoot growth, yield components, and fruit composition.

Methods and Material

This study was carried out in two 'Blanc Du Bois' vineyards located in the Rio Grande Valley (26.1, -97.9) and Central Gulf Coast (29.7, -96.8) of Texas from 2011 to 2014. The soils were, as classified by the USDA, Carbengle Series, thermic Udic Calciustolls (https://soilseries.sc.egov.usda.gov/OSD_Docs/C/CARBENGLE.html), and Raymondville Series, hyperthermic Vertic Calciustolls (https://soilseries.sc.egov.usda.gov/OSD_Docs/R/RAYMONDVILLE.html), at the Rio Grande Valley and Central Gulf Coast sites, respectively. At the Rio Grande Valley site, 'Blanc Du Bois' vines were grafted on ‘Dog Ridge’ rootstock and were planted in 2009. Rows were oriented north-south with 3.66 m between rows and 1.83 m between vines. Four training systems were evaluated as follows: Mid-Wire Bilateral Cordon with VSP (MWC), consisting of a fruiting wire at 1.02 m in height with three sets of catch wires spaced at 25 cm intervals above the cordon wire, Mid-Wire Bilateral Cane (CANE) pruned to four canes positioned on two parallel fruiting wires at 1.02 m in height and 25 cm apart with three sets of catch wires spaced at 25 cm intervals above the fruiting wire, the Watson Training System (WAT) consisting of bilateral cordons positioned at 1.68 m in height and two sets of parallel wires spaced at 15 cm intervals above the fruiting wire and spaced at 0.6 m and 1.22 m apart on a 120° v-cross arm (Westover 2013), and Quadrilateral High-wire Cordon (QUAD) with bilateral cordons at a height 2.13 m at a width of 1.22 m.

At the Central Gulf Coast site, vines were ungrafted and were planted in 2009. Rows were oriented north-south with 3.04 m between rows and 1.83 m between vines. Three training systems were evaluated: Mid-Wire Bilateral Cordon (MWC) with VSP, consisting of a fruiting wire at 1.02 m in height with three sets of catch wires spaced at 25 cm intervals above the cordon wire, Mid-Wire Bilateral Cane (CANE) pruned to four bilateral canes positioned on a fruiting wire at 1.02 m in height with three sets of catch wires spaced at 25 cm intervals above the cordon wire, and Smart-Dyson Training System (SD) consisting of a cordon wire at 1.02 m in height with three sets of catch wires spaced at 25 cm intervals above the cordon wire and a rake wire at 51 cm in height to facilitate positionig shoots downward.

The experimental design at each site was a randomized complete block with six replications. The experimental plots consisted of two interior rows and each replicate consisted of three consecutive vines. Vineyard management was performed according to standard practices for 'Blanc Du Bois' in the Gulf Coast Region. Vines were pruned to a bud density of 15 count buds per meter of canopy for all training systems. Canopy management consisted of shoot positioning based on vine phenology, and no shoot, leaf, or cluster thinning was performed.

Pruning Weight

Winter pruning was conducted in the first to second week in February in the Rio Grande Valley and the fourth week of February to first week of March in the Central Gulf Coast site which corresponded to approximately one to two weeks prior to bud break. Cut-off canes were collected from each vine and weighed using a Pelouze model 7710 digital hanging scale (Rubbermaid, Atlanta, GA) and mean cane weight was determined as total cane pruning weight divided by the number of canes. Canes that were less than 25 cm in length were not measured.

Yield Components

Harvest was carried out between 115 and 125 days after bud break at both sites which corresponded to the last two weeks of June to the first two weeks of July at the Rio Grande Valley and Central Gulf Coast sites, respectively. Yield was determined on individual vine basis using a Rubbermaid model H-480 platform scale (Rubbermaid, Atlanta, GA) and mean cluster weight was calculated as vine yield divided by the total number of clusters per vine. A 100-berry sample was collected at random from each replicate, and a Mettler ME 204 balance (Mettler Toledo Inc., Columbus, OH) was utilized to determine mean berry weight. The berry samples were then frozen at -23°C until chemical analysis was performed.

Berry Analysis for Soluble Solids, Total Acidity, and pH.

Berry samples were removed from the -23ºC freezer, placed in a 250-mL beaker and heated to 65ºC for one hour in a water bath to redissolve tartrates, pressed through cheesecloth with a pestle, and the juice was collected for analyses. Soluble solids contents (ºBrix) were measured using a digital refractometer (model 300017; SPER Scientific, Scottsdale, AZ) with temperature correction. Total acidity (TA) and pH were measured with an automatic titrater (Titrino model 798, Metrohm, Riverview, FL). TA was measured with a 5.0-mL aliquot of juice by titration against 0.1 N NaOH to pH 8.2.

Statistical Analysis.

Data were subjected to the Proc GLM procedure using SAS® statistical software (SAS Institute, Cary, North Carolina) and means were separated using Tukey's Honestly Significant Difference (HSD) test at the 5% significance level. Data from each site and each year were analyzed separately, and data from each site were analyzed over years.

Results and Discussion

The two vineyard sites utilized in this study represented significant differences in vigor potential as evidenced by dormant pruning weights (Tables 1, 2). At the Rio Grande Valley site, vines were grafted on Dog Ridge rootstock (*V. champini*) due to alkaline soil conditions and potential of cotton root rot (*Phymatotrichum omnivorum*) at the site (Mortensen and Randolph 1940). This vigorous rootstock, combined with a very long growing season resulted in extremely high cane pruning weights that averaged from 3.71 to 5.56 kg per vine across training systems over the course of the study. The post-harvest season in the Texas Rio Grande Valley is typically as long as the period of time from bud break to harvest for 'Blanc Du Bois' (115 to 125 days), thus significant growth occurred after harvest. Furthermore, due to the relatively mild winters in the region (USDA Cold

Hardiness Zone 10a), green cane tissue and leaves from the previous growing season were present at pruning further increasing dormant cane weights.

Table 1.

Impact of training system on yield components and vine size of 'Blanc Du Bois' in the Rio Grande Valley.

Treatment	Clusters/ vine	Yield/ vine (kg)	Cluster weight (g)	Canes/ vine	Mean cane weight (g)	Pruning weight (kg)	Clusters/ shoot	Ravaz index
2012								
CANE[a]	4.54c[c]	0.52c	144.4	20.22b	341.7a	6.49b	0.25b	0.09
MWC	6.17c	0.66c	120.2	19.81b	341.1a	6.52b	0.31b	0.11
WAT	18.13b	2.02b	120.4	23.27b	372.1a	8.47a	0.79a	0.26
QUAD	34.71a	4.17a	118.7	31.48a	179.6b	5.65b	1.11a	0.78
Significance[b]	***	***	ns	***	**	*	***	ns
2013								
CANE	9.86c	1.60c	161.2bc	27.33b	141.3b	4.70b	0.35b	0.33c
MWC	6.74c	2.56c	157.3c	35.86a	221.1a	5.88a	0.19b	0.41c
WAT	32.07b	6.07b	190.5ab	36.39a	164.6b	4.86b	0.93a	1.32b
QUAD	48.31a	10.00a	201.2a	39.50a	55.9c	3.07c	1.46a	3.20a
Significance	***	***	***	**	***	***	***	***
2014								
CANE	110.1b	9.25b	110.1	28.92b	140.5a	4.28a	4.03	1.94b
MWC	125.7b	11.60b	125.2	35.02ab	131.0a	4.69a	3.77	2.49b
WAT	125.2b	14.40ab	125.2	36.52ab	111.6ab	4.00a	3.61	3.32a
QUAD	192.2a	17.80a	178.4	40.29a	61.0b	2.39b	4.76	6.29a
Significance	**	**	ns	*	*	***	ns	**
Multi-year Mean								
CANE	41.48b	3.79b	135.4	26.02b	222.97a	5.38ab	1.54b	0.79
MWC	47.99ab	4.94b	130.3	30.43b	200.16a	5.49a	1.42b	0.97
WAT	58.46ab	7.49ab	166.2	32.09ab	205.43a	5.56a	1.77ab	1.70
QUAD	94.01a	10.66a	143.4	37.35a	106.46b	3.71b	2.44a	3.42
Significance	***	***	ns	***	***	***	**	***
Year x Treatment	ns	ns	ns	ns	ns	ns	ns	**

[a]CANE, MWC, WAT, and QUAD are Mid-Wire Cane pruned with VSP, Mid-Wire Cordon with VSP, Watson, and High-Wire Qudralateral training systems, respectively.

[b]ns, *, **, and *** indicate not significant, and statistically significant at the 0.05, 0.01, and 0.001 level of probability, respectively.
[c]Means followed by different letters are significantly different at the 95% level (Tukey's HSD).

Table 2.

Impact of training system on yield components and vine size of 'Blanc Du Bois' in the Central Gulf Coast.

Treatment	**Clusters/ vine**	**Yield/ vine (kg)**	**Average cluster weight (g)**	**Cane/ vine**	**Pruning weight (kg)**	**Mean cane weight (g)**	**Clusters/ cane**	**Ravaz index**
2011								
CANE[a]	88.00a[a]	8.56a	101.08b	27.83	1.78	66.27	3.25a	4.96a
MWC	25.89b	3.11b	121.04a	27.14	1.64	65.73	0.90b	1.70b
SD	29.56b	3.48b	118.44a	27.83	1.87	57.72	1.01b	2.16b
Significance[b]	***	***	*	ns	ns	ns	*	***
2013								
CANE	22.94a	2.55	143.33b	27.61b	1.54	57.35	0.83a	1.67
MWC	15.17b	3.32	176.86a	27.11b	1.79	67.80	0.57b	1.89
SD	23.06a	3.15	135.20b	31.50a	1.81	57.73	0.73ab	1.73
Significance	**	ns	*	*	ns	ns	**	ns
2014								
CANE	20.83a	2.71	167.99b	-[d]	-	-	-	-
MWC	13.28c	3.33	215.71a	-	-	-	-	-
SD	16.50b	2.91	178.91b	-	-	-	-	-
Significance	**	ns	*	-	-	-	-	-
Multi-year Mean								
CANE	43.93	3.50	137.46b	27.72	1.66	61.80	2.05a	3.56
MWC	17.38	5.58	171.20a	28.12	1.83	66.76	0.73b	1.57
SD	23.04	4.12	144.88b	30.28	1.73	57.73	0.87b	1.95
Significance	***	***	**	ns	ns	ns	***	***
Year x Treatment	***	***	ns	ns	ns	ns	ns	***

[a]CANE, MWC, and SD are Mid-Wire Cane pruned with VSP, Mid-Wire Cordon with VSP, and Smart-Dyson training systems, respectively.
[b]ns, *, **, and *** indicate not significant, and statistically significant at the 0.05, 0.01, and 0.001 level of probability, respectively.

[c]Means followed by different letters are significantly different at the 95% level (Tukey’s HSD).
[d]Data not available.

The high vigor at the Rio Grande Valley site was also evident by the high cane weights observed and the low number of canes per vine in the CANE treatment. This resulted from long internodes on the fruiting canes that were retained each season. On average, cane density, expressed as the number of canes removed at pruning per meter of canopy, ranged from 11.03 to 15.8, or an average of 5.04 canes were removed from each fruiting cane (4 fruiting canes per vine). This led to lower yields than the divided canopy systems, and lower bud fruitfulness was also observed in both of the mid-wire training systems. The number of clusters per shoot averaged 1.42 and 1.54 for the CANE and MWC treatments, respectively, compared to 1.77 and 2.44 for the WAT and QUAD treatments, respectively. The lower position of the fruiting zone with respect to the canopy, combined with the high vigor and semi-procumbent growth habit of 'Blanc Du Bois' likely led to shading of the lower bud positions in the mid-wire training systems. Shading of shoots and buds has been widely reported to reduce bud fruitfulness (Buttrose 1974a, May 1965, Perez and Kliewer 1990, Williams 1994, Williams 2000, Winkler et al. 1974, Li-Mallet et al. 2016).

The ratio of yield to pruning weight (Ravaz Index) at the Rio Grande site indicated that all training systems were undercropped based on general recommendations for *V. vinifera* (Bravdo et al. 1985) and hybrid grapes (Reynolds et al. 2004). However, the average yield per vine ranged from 3.79 to 10.66 kg across training systems over the course of the study. Based on the row and vine spacing at the site, this is extrapolated to 5,664 to 15,930 kg/ha. Thus, the low Ravaz values did not reflect low yields, but rather very high pruning weights. As stated previously, the high pruning weights may not reflect the size and thus capacity of the vines when they carried fruit as significant post-harvest growth occurred. Therefore, the yield to pruning weight ratios suggested for hybrid grapes may not apply here.

From 2012 to 2014, yields generally increased each year at the Rio Grande Valley site as a result of higher cluster numbers. This may be attributed to more fruiting shoots and higher bud fruitfulness as both were observed over time, but fruitful non-count shoots may have also contributed. While the fruitfulness of non-count shoots has not been reported in Blanc Du Bois, the high number of clusters in 2014 relative to the number of canes suggests that the vines produced fruitful, non-count shoots that remained small and were therefore, not counted as canes at pruning. Only canes that were greater than 25 cm in length were counted and weighed. High fruitfulness of non-count shoots has been widely in other hybrid grape cultivars and this may also be a characteristic of Blanc Du Bois (Ferree et al. 2003, Kurtural et al. 2006Morris et al. 2004, Pool et al. 1978, Reynolds 1989).

Overall, the QUAD training system maintained the most favorable vine growth characteristics over the course of the study based on lower dormant pruning and mean cane weights, higher clusters/shoot and a higher Ravaz Index. However, in 2014, QUAD had lower soluble solids than MWC and lower pH than MWC and CANE indicating that the fruit was less mature at harvest (Table 3). This was likely a result of the relatively large crop, although the data collected on vine size did not suggest overcropping based on previous recommendations.

Table 3.

Impact of training system on juice chemistry for Blanc Du Bois in the Rio Grande Valley in 2014.

Treatment	TSS (°Brix)	TA	pH
MWC	19.17a[c]	7.54	4.11a
CANE	17.58b	7.10	4.14a
QUAD	16.67b	7.58	3.97b
WAT	17.60b	7.53	4.02b
Significance[b]	*	ns	*

[a]CANE, MWC, WAT, and QUAD are Mid-Wire Cane pruned with VSP, Mid-Wire Cordon with VSP, Watson, and High-Wire Qudralateral training systems, respectively.
[b]ns, *, **, and *** indicate not significant, and statistically significant at the 0.05, 0.01, and 0.001 level of probability, respectively.
[c]Means followed by different letters are significantly different at the 95% level (Tukey's HSD).

The juice TA for all training systems at the Rio Grande Valley site were within an acceptable range for white wines, but pH values were high suggesting that potassium may have played a role (Boulton 1980). Higher concentrations of potassium have been reported in musts from *V. champini* rootstocks compared to own-rooted grapevines (Cirami et al. 1984, Walker et al. 1998). High juice pH was also observed at the Central Gulf Coast site in 2013 (Table 4), but the TA was lower and soluble solids content were higher suggesting that the fruit may have reached more advanced maturity. At both sites, soluble solids ranged from 16.67 for QUAD to 19.17°Brix for MWC in the Rio Grande Valley site and 18.08 for CANE to 21.58°Brix for SD at the Central Gulf Coast site which is consistent with other reports on mature 'Blanc Du Bois' fruit chemistry (Ames et al. 2016, Mortensen 1987). In the Central Gulf Coast site in 2013, the MWC treatment had the highest juice pH and lowest TA suggesting more advanced maturity. The MWC vines had fewer clusters than the other training systems during the 2013 growing season, but vine yields were not significantly different as a result of larger clusters.

Table 4.

Impact of training system on juice chemistry for Blanc Du Bois in the Central Gulf Coast.

Treatment	TSS (°Brix)	TA	pH
2013			
MWC[a]	20.82	5.58c[c]	4.02a
CANE	20.45	6.40b	3.91b
SD	21.58	7.30a	4.07a

Treatment	TSS (°Brix)	TA	pH
Significance[b]	ns	**	*
2014			
MWC	18.20	7.93	3.84
CANE	18.08	7.90	3.83
SD	18.15	7.69	3.86
Significance	ns	ns	ns
Multi-year Mean			
CANE	19.26	7.14	3.87b
MWC	19.50	6.75	3.92ab
SD	19.87	7.49	3.96a
Significance	ns	**	*
Year x Treatment	ns	***	ns

[a]CANE, MWC, and SD are Mid-Wire Cane pruned with VSP, Mid-Wire Cordon with VSP, and Smart-Dyson training systems, respectively.
[b]ns, *, **, and *** indicate not significant, and statistically significant at the 0.05, 0.01, and 0.001 level of probability, respectively.
[c]Means followed by different letters are significantly different at the 95% level (Tukey’s HSD).

The vines at the Central Gulf Coast site were less vigorous and had higher crop load values than those at the Rio Grande Valley site (Table 2). However, training system did not influence vine size, and it did not consistently impact yield components and crop load. In the first year of the study, the CANE treatment had a higher yield than the MWC and SD treatments as a result of more fruit clusters, and this also led to a higher crop load, but it was not observed in the following seasons. The only consistent differences between training systems across the three years of study were mean cluster weight and clusters/cane. The MWC treatment produced larger clusters (171.20 g/cluster) than the CANE (137.46 g/cluster) and SD (144.88) treatments, but no differences in berry weight were observed (data not shown). Therefore, the larger clusters may be attributed to a greater number of berries per cluster. 'Blanc Du Bois' clusters are moderately compact, thus relatively high levels of fruit set may not be desirable, particularly in humid regions where 'Blanc Du Bois' is most commonly grown.

The CANE treatment had a greater number of clusters/cane than MWC and SD treatments and it is not possible to completely rule out the influence of canopy microclimate on bud fruitfulness, although the data collected to characterize vine size do not indicate differences in vine vigor or shoot density. More likely, the CANE treatment had more fruitful shoots as a result of their location along the cane versus the shoots arising from more basal locations on the spurs of the MWC and SD treatments. Differences in bud fruitfulness, based on cane position, has been reported for multiple grape cultivars (Antcliff and Webster 1955, Buttrose 1974b, Sanchez and Dokoozlian 2005, Li-Mallet et al. 2016). Cane pruning may be an option for 'Blanc Du Bois' growers that wish to increase yield on low to moderate vigor sites, although the practice is typically considered to be more laborious than spur pruning.

Overall, the three training systems evaluated at the Central Gulf Coast site all produced commercially acceptable yields, pruning weights, and juice chemistry. However, on more vigorous sites, SD could be advantageous due to its capacity to carry a greater number of shoots. In 2013, the SD training system had four more canes than MWC and CANE, but had a much lower shoot density, when expressed as canes per meter of canopy (SD = 8.6, MWC = 15.1, CANE = 14.8). Therefore, the potential of the SD training system to accommodate twice as many shoots, and maintain the same shoot density as a single canopy training system, was not realized.

Conclusion

This research evaluated the impact of divided and undivided training systems on 'Blanc Du Bois' vine performance. On a site with high vigor potential, the horizontally divided canopy training systems Watson and High-Wire Quadrilateral outperformed Mid-Wire Cordon with VSP and Mid-Wire Cane-pruned with VSP, with respect to pruning weight and vine yield. On the second site, where vigor potential was lower, all of the training systems under study (Mid-Wire Cordon with VSP, Mid-Wire Cane with VSP, and Smart-Dyson) had acceptable pruning weights, yield, and juice composition, although the vertically divided canopy system, Smart-Dyson, may be superior on sites with higher vigor potential resulting from soil or climate.

Hosting institution

Texas A&M University

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