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Effect of Crop Levels and Pruning Timing on Bunch and Berry Parameters of Cabernet Sauvignon Grapes

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ABSTRACT

The vines were pruned at 3 timings and crop levels of 20, 30 and 40 bunches per vine were maintained. The dynamics of TSS, Acidity and pH was directly affected by increased degree days and sunshine hrs in the berries collected from maintained crop levels. The TSS values of berries were found positively correlated with degree days and sun shine hours while total acid contents were negatively correlated in each and every sampling. However, in early samplings correlation values were higher and decreased at D3 and D4 that is 118 and 126 days after pruning. In case of first pruning the maturity index was increased with increasing crop level and maximum index i.e.282.11 was observed in P1XCL3.In case of P3, maturity index was reduced and the berries collected from maximum bunch load fail to come within range of suitability. Effect of crop levels and pruning timings were clearly noted on bunch and berry parameters. Bigger bunches were found from P2 and smallest bunches were in P1. The third pruning with maximum crop level was resulted in minimum TSS content in berries. Grape berries collected from the vines maintained a crop level of 30 bunches and pruned on 5th Oct were having suitable physico-chemical parameters for making good wines.

Keywords: Crop levels, berry, degree days, maturity index, dynamics

INTRODUCTION

Adaptability of wine grape varieties has been well established in tropical conditions of India. Cabernet Sauvignon is main red wine grape variety which is adopted in this region. Vines are pruned during September - October and bunches become ready for harvesting during January to March in Maharashtra. But, no research work on suitable pruning time and crop level to achieve grapes with desired quality parameters has been attempted. One crop from double pruning under these conditions makes it different from other grape growing regions. The vines are trained to mini Y system considering prevailed weather conditions and vine vigour. Wine grape varieties like Cabernet Sauvignon, Shiraz, Merlot, Chenin Blanc, Sauvignon Blanc, Chardonnay etc. are performing very well and wineries are making wines from these varieties (Adsule*et al.*, 2012).Initially, wineries in tropical climate used to follow production technologies similar to traditional old world wine producing countries. Since, climatic conditions are different than temperate regions, these production technologies did not work well and hence new and specialized techniques and equipment are introduced in tropical wine grape production system. The quality of grapes has been improved tremendously, after the establishment of two pruning and single cropping cultivation practices (Jogaiah*et al.*, 2013).Time of pruning as well as crop levels directly affect bunch and berry parameters.Fruit pruning of vines is performed during September - October and the bunches become ready for harvesting during January toMarch in tropical conditions of Maharashtra. But, there are no well documented research findings on pruning time of particular variety in this region.The quality of wine is decided by grapes from which wine is made. Various factors like variety and rootstock on which it is grafted, soil and climatic conditions, training andpruning, water, nutrition, incidence of insect-pests and diseases etc. affect the winegrape quality. Other than these factors, maturity of grapes at the time of harvestingdecides wine quality. There are many aspects of grape maturity that determine the besttime to harvest winegrapes (Sharma *et al.*,2013). Pruning and harvesting practices in vineyards decided considering the grape requirements of wineries with desirable TSS. Beside pruning time, crop level has own impact on wine quality. Well balanced grapevines that do not over crop and ripen their fruit to desired soluble solids within a given accumulation of degree days (Kliewer and Dokoozlian 2005). It is also widely believed that high-yielding vines produce lower-quality wines.The relationship between the crop level and the wine quality has been widely investigated and reviewed from various wine regions.Considering the importance of pruning time and crop levels the present study was performedon Cabernet Sauvignon vines grafted on 110R rootstock and grown under tropical conditions of Pune.

MATERIAL AND METHODS

The vines of Cabernet Sauvignon grafted on 110R rootstock and spaced a distance of 2.438 X 1.219 m, were selected for the experiment. The vines were pruned on28th Sep 2011, 5th Oct and 12th October 2011 as first pruning (P1), second pruning (P2) and third pruning (P3), respectively. The crop levels of 20, 30 and 40 bunches per vine were maintained as CL1, CL2 and CL3, respectively.The samples were collected on 19th Jan, 27th Jan, 2nd Feb, 10th Feb, 16th Feb and 22nd Feb to study dynamics of TSS, pH and total acids in the berries. The data on total acidity,

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TSS, pH was noted by usingOenoFoss™ (FTIR based wine analyser).The grapes were harvested when berries attained desired TSS. The degree days were calculated.TSS and total acid content were correlated with degree days and sunshine hours. The maturity index was calculated by method of TSSX pH^2(Coombe *et al.*, 1980). In each treatment, 10 vines were identified randomly and earmarked. Each treatment was replicated thrice. A total of 4 bunches were collected from each vine to estimate various bunch parameters. A group of about 100 berries, representing each and every vine was used to estimate berry parameters like pH, TSS and acidity. Standard procedures were followed to note bunch and berry parameters. Three separate samples were collected from each treatment and analysed. The collected data were statistically analysed by using SAS program.

RESULTS AND DISCUSSION

Dynamics of TSS, pH and acidity in berries collected from different crop levels

The data on degree days attained on sampling dates are presented in Table 1. First sampling (D1) was noted with degree days of 1492.1, 1384.75 and 1256.5 in first, second and third pruning, respectively.

Delay in sampling was found with more degree days. On overall basis, first pruning recorded more degree days followed by second and third. The data on TSS, pH and acidity of berries was collected from the bunches harvested on 105 (D1), 112 (D2), 118 (D3), 126 (D4), 132 (D5) and 138 (D6) days after pruning. The data showed that accumulated degree days and sunshine hrsin D1 were 1384.75 and 1133.67, respectively and these values were increased up to 1789.25 and 1486.67, respectively in D6. The increased degree days and sunshine hrs in giving duration of between D1 and D6 (33 days)were 404.50 and 353, respectively.

The dynamics of TSS, acidity and pH was directly affected by increased degree days and sunshine hrs in the berries collected from the crop levels of 20, 30 and 40 bunches/vine. In case of TSS, an increment of 7.38 °B was noted in CL1 from sampling of D1 to D6, while this value was 7.55 °B in CL2 and 7.7 °B in CL3 for given duration of 33 days(Table 2).The acidity was decreased during the sampling period of D1 to D6. Acidity content of 11.52 g/L was noted at D1 in all crop levels which was reduced up to 4.18, 3.83 and 4.06 g/L in CL1, CL2 and CL3, respectively.It means in the early days, levels of acidity and pH were same but by accumulation in degree days and more exposure to sunshine hrs, the differences were appeared.

Table 1: Degree days attained by Cabernet Sauvignon on different dates of sampling

Pruning	Degree days on sampling dates					
	19 Jan	27-Jan	02-Feb	10 -Feb	16-Feb	22-Feb
I pruning	1492.10	1588.60	1662.85	1774.00	1837.10	1907.05
II pruning	1384.75	1481.25	1555.50	1656.20	1719.30	1789.25
III pruning	1256.50	1353.00	1427.25	1527.95	1591.05	1661.00

Table 2: TSS, acidity and pH of berries collected from various crop levels between 105 to 138 days after pruning.

Duration of crop in days	Degree Days	Sunshine hrs.	TSS (°B)			Acidity (g/L)			pH		
			CL1	CL2	CL3	CL1	CL2	CL3	CL1	CL2	CL3
D1 (105)	1384.75	1133.677	13.45	12.82	12.65	11.52	11.52	11.52	2.89	2.89	2.89
D2 (112)	1481.25	1218.510	15.56	15.53	14.67	9.62	9.11	9.50	2.90	2.95	2.96
D3(118)	1555.50	1283.260	17.30	17.62	17.25	7.73	7.43	7.05	3.01	3.02	3.01
D4 (126)	1656.20	1369.593	18.83	19.20	19.22	5.30	5.55	5.36	3.17	3.14	3.17
D5 (132)	1719.30	1434.760	19.66	20.77	20.52	5.06	5.05	4.78	3.17	3.18	3.20
D6 (138)	1789.250	1486.677	20.83	20.37	20.35	4.18	3.83	4.06	3.37	3.40	3.35

(CL1: 20 bunches/vine, CL2: 30 bunches per vine and CL3: 30 bunches per vine)

Decreased acidity in maintained crop levels viz.; CL1, CL2 and CL3 were 7.34, 7.69 and 7.46 g/L, respectively. The pH value of must from different crop levels at D1 was same *i.e.* 2.89 and it was increased up to 3.37, 3.40 and 3.35 in CL1, CL2 and CL3, respectively (Fig. 1,2 and 3).

Data on correlation of degree days and sunshine hours with TSS and total acid content of berries are presented in Table 3. The TSS content in berries were found positively correlated with degree days and sunshine hours while total acid contents were negatively correlated in each and every sampling time.

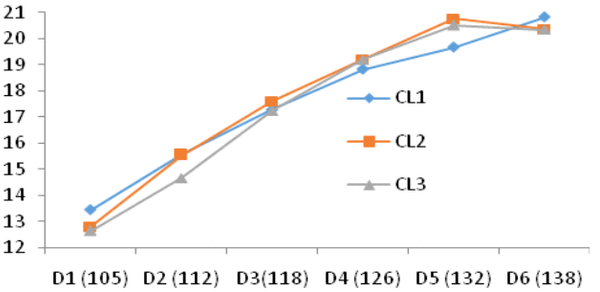

Fig. 1: **Dynamics of TSS (°B) at different crop levels**

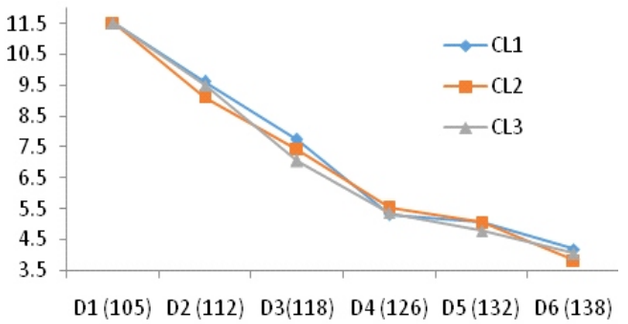

Fig. 2: **Dynamics of acidity (g/L) in berries at different crop levels**

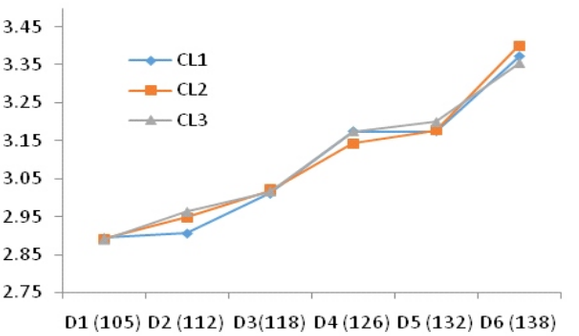

Fig. 3: **Dynamics of pH of juice of berries at different crop levels**

However, in early samplings, correlation values were higher and decreased at D3 and D4 i. e. 118 and 126 days after pruning. At these levels, degree days and sunshine hrsin D3were 1555.50 and 1283.26 respectively,ans 1656.20 and 1369.59 in D4.

Table 3: Correlation of degree days and sunshine hrs with TSS and total acids

Duration of crop in days	Date of samplings	Correlation with degree days		Correlation with sunshine hrs	
		TSS	Total Acids	TSS	Total Acids
D1 (105)	19 th Jan	0.977691	-0.97362	0.975571	-0.97607
D2 (112)	27 th Jan	0.906462	-0.99032	0.907477	-0.99082
D3(118)	2 nd Feb	0.978203	-0.98363	0.976623	-0.98307
D4 (126)	10 th Feb	0.923700	-0.98664	0.920012	-0.98794
D5 (132)	16 th Feb	0.883057	-0.96729	0.876834	-0.97241
D6 (138)	22 nd Feb	0.753988	-0.89289	0.745794	-0.90107

Maturity Index

All values of maturity index were found within limit of suitability of grapes for wine making i.e. 200 to 270 (Coombe *et al.*, 1980),except combination of P3XCL3 (Table 4). In case of first pruning the maturity index was increased with increasing crop level and maximum index (282.11) was observed in P1XCL3. While in case of P3 reverse trend was noted. In case of P3, maturity index was reduced and the berries collected from maximum bunch load failed to come within range of suitability. This clearly indicated that the crop level as well as pruning time significantly affected maturity index of berries. Calculated maturity Index revealed positive correlations with degree days and sunshine hours with the values of 0.932875 and 0.934378, respectively.

Table 4: Degree days, sun shine and maturity index attained on VI sampling by combinations of prunings and crop levels

Combinations	Maturity Index	Degree days	Sunshine
P1xCL1	260.30	1907.05	1572.51
P1xCL2	279.01	1907.05	1572.51
P1xCL3	282.11	1907.05	1572.51
P2xCL1	233.29	1789.25	1486.677
P2xCL2	228.43	1789.25	1486.677
P2xCL3	237.37	1789.25	1486.677
P3xCL1	216.92	1661.00	1401.677
P3xCL2	203.33	1661.00	1401.677
P3xCL3	175.30	1661.00	1401.677
Correlation values		0.932875	0.934378

Bunch and berry parameters

Bunch weight, berries/bunch and TSS content of berries were significantly affected by prunings however, non-significant differences were noted in average berry weight and berry diameter. Bigger size bunches were found in P2 and smallest bunches were observed in P1. Almost same trend was observed in case of berries/ bunch. But, maximum TSS was in P1 followed by P2. The results in case of crop levels were followed almost same trend. The lower level was noted with higher bunch load and berries per bunch. Higher crop level (40 bunches/vine) contained maximum TSS (23.55 °B) in berries. The interaction showed significant differences in bunch weight and TSS while other parameters showed non-significant differences. Minimum berry diameter (9.66 mm) was registered in P2XCL3 indicating its significance in making quality wines. Same treatment was recorded with maximum TSS of 24.40 °Band the same TSS value was in P1XCL3 also. Minimum TSS was recorded in berries of P3 having maximum bunch load (Table 5).

Table 5: Effect of pruning time and load on bunch and berry parameters

Treatments	Parameters				
	Bunch Weight (g)	Average berry wt (g)	Berries/bunch	Berry diameter (mm)	TSS (°B)
Pruning					
P1	86.45	9.0167	95.66	12.00	23.42
P2	113.92	8.8433	129.66	11.05	23.26
P3	106.88	8.8300	117.44	11.61	22.46
LSD (5%)	15.226	NS	22.766	NS	0.855
Crop load					
CL1	113.23	8.8344	131.11	11.66	22.93
CL2	92.45	9.2911	99.88	12.11	22.66
CL3	101.58	8.5644	111.77	10.88	23.55
LSD (5%)	15.226	0.6628	22.766	NS	0.855
Interaction of PXCL					
P1xCL1	89.41	8.6733	99.00	12.33	22.46
P1xCL2	87.47	9.4733	92.33	11.66	23.40
P1xCL3	82.48	8.9033	95.66	12.00	24.40
P2xCL1	126.77	8.5933	155.33	11.33	23.00
P2xCL2	101.71	9.5833	113.33	12.16	22.40
P2xCL3	113.29	8.3533	120.33	9.66	24.40
P3xCL1	123.52	9.2367	139.00	11.33	23.33
P3xCL2	88.17	8.8167	94.00	12.50	22.20
P3xCL3	108.97	8.4367	119.33	11.00	21.86
LSD (5%)	44.255	NS	NS	NS	2.488

Quality of wine grapes used for fermentation of has positive impact on end product i. e. wine. Among the physico-chemical parameters of grape berries, sugar, acidity and pH play an important role in deciding alcohol content, sensory properties and stability of wines. After veraison,heat plays an important role in sugar accumulation and the rate of other metabolic activities increases during ripening. Generally, TSS in berries increases during maturation while, at berry growth stages sugars are used for growth and seed development. After veraison, a metabolic change occurs enabling sugar accumulation in the berry during maturation (Falcão *et al.,* 2008). Crop level management by cluster thinning hasdirect influence on yield but did not affect berry weight or berries per cluster. Anderson *et al,* (2007) recorded significant differences in Brix, pH and titratable acidity. However, these differences were, rather small in amplitude and diminished with the season. TSS accumulation showed enologically significant differences 50 days before harvest but, at harvest, fruit from all treatments had similar TSS content. The increased content of TSS was recorded in present study also. By increasing degree days, the TSS content of grape berries was increased at different crop levels. But extended season results in lesser differences and similar pattern was noted by Anderson *et al,* (2007) also. Massive accumulation of glucose and fructose in the vacuoles of mesocarp cells occurs after véraison. Twenty days after this period, the hexose content of the berry increases and ratio of glucose/fructose become 1. Because sucrose is the major translocated sugar in grapevine, the rapid accumulation of hexose characterizing berry ripening must involve the activity of invertases (Conde *et al.,* 2007 and Fillion *et al.,* 1999).Advancement of season resulted in increased pH values and decreased acid content in berries at different crop levels. Accumulation of degree days means more temperature result in higher pH and low acid concentrations due to the respiration of organic acids. As a general trend, the pH increased along with the sugar concentration as grapes matured and total acids declined (Butzke and Boulton, 1997).In grape berries, tartaric and malic acids constitute most (up to 92 %) of the total TA (Kliewer 1966) and that respiration of berry acids, particularly malic acid, increases with increasing temperatures (Coombe 1987; Sweetman *et al.,*2009). A positive pH average evolution was observed by Falcão *et al,* (2008) from pH 2.8 at véraison to pH 3.8 at harvest. The results obtained in present study were also found in same manner. Advancement in sampling time showed positive correlation of TSS with degree days and sunshine accumulation, while negative correlation was noted in case of acidity. Petrie and Sadras (2008) demonstrated that higher growing season temperature resulted in increased rates of sugar accumulation and advanced fruit maturity dates.

The quantity of clusters per plant affects the size of the clusters and that of the fruit, and therefore, the accumulation of sugar (Iacono *et al.,* 1995). Berry size is widely recognized as an important factor determining wine grape quality. Singleton (1972) estimated the role of berry size by removing and adding juice at crushing. However, there were no indications of larger berries have more juice/solids.When crop level was altered several fold by establishing a high crop load and thinning to different numbers of clusters at veraison, berry size and berry composition were largely unaffected, but the time required to reach 23.5, 24, and 25°Brix was linearly dependent on crop level (Nuzzo and Matthews, 2006). However, non-significant differences were noted specially in berry diameter. But other parameters like bunch weight, berries per bunch and TSS were having significant differences in case of pruning time and crop levels. The interaction effects were having mostly non-significant except bunch weight and TSS content in berries. Jogaiah *et al,* (2013) also reported higher bunch weight in Cabernet Sauvignon when cluster thinning was performed. The increased berry weight in cluster thinned vines was due to diversion of photosynthesis in to remaining clusters on the vine. Bunches developed on control vines showed least berry weight.

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