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Cluster thinning influences photosynthetic activity, fruit composition and wine quality of grapes under tropical environment

R. G. Somkuwar*, M. A. Bhange, A. K. Sharma, D. P. Oulkar and Aarti K. Bhongale
ICAR-National Research Centre for Grapes, P.B. No. 3, Manjri Farm Post, Pune 412 307, Maharashtra

ABSTRACT

A field experiment was conducted during the year 2014-15 to study the effect of cluster load on yield, berry quality, gas exchange and biochemical changes in Chenin Blanc and Syrah wine grape varieties. Cluster load was adjusted to 40, 60 and 80 clusters/vine. Significant differences were observed for all physicochemical and biochemical parameters. The increased bunch weight in Chenin Blanc (112.88 g) and Syrah (92.44 g) was recorded with the reduction in number of clusters per vine (40 clusters). The same trend was also observed for 100 berry weight. The reduction in cluster load/vine increased the total soluble solids in berries of both the varieties. Significantly higher rate of photosynthesis was recorded with maximum cluster load in Chenin Blanc while in Syrah variety; the rate of photosynthesis was highest with reduced cluster load. In Chenin Blanc, highest concentrations of reducing sugar, proteins, phenols and total carbohydrate were recorded in 40 clusters/vine. On the other hand, in Syrah variety, it was with 60 clusters/vine. The titratable acidity and pH of the must was significantly influenced by cluster thinning treatments. The vines with minimum clusters (40 clusters) showed minimum titratable acidity and pH while the maximum clusters load increased titratable acidity and pH. It was observed that the source: sink alteration by cluster load in both the varieties had positive impact on yield, berry quality, sugar accumulation, gas exchange parameters and biochemical composition.

Key words: *Vitis vinifera*, cluster load, must quality, yield.

INTRODUCTION

As per an estimate, total area of 139 thousand ha is covered under grape cultivation with production of 2.98 million tons during 2017-18 (Anonymous, 2). Presently about 7000-acre area is covered under wine grape production mainly in Maharashtra and Karnataka states. Wine quality is mainly affected by quality of grapes. Canopy management practice includes retention of shoots and bunches, exposure of bunch to sunlight, etc. Exposure of bunches to sunlight during veraison to maturity decides quality of wine produced from the grapes. Vine health for nourishing the bunch during berry development stage is important. Arrangement of open canopy can help to improve the photosynthesis thereby increasing storage of food material.

Cluster thinning aims to improve the grape quality through enhanced anthocyanin and phenolic accumulation in red cultivars (Gil-Munoz *et al*., 8). Gatti *et al*. (7) in their studies on effect of cluster thinning and pre-flowering leaf removal on fruit composition of Sangiovese grapes observed high brix level corresponded to the highest TA in defoliated vines and conversely the lowest TA and high pH in early cluster thinning and lag phase cluster thinned vines. Somkuwar *et al.* (19) reported increased yield with higher number of buds owing to greater number of clusters produced with reduced sugar content. However, there is a practice of removing clusters at the berry stage of 3-4 mm. which is believed necessary for improving the wine quality. Considering the importance of wine quality and influencing factors, a study was conducted to know the effects of cluster retention on fruit composition and wine quality of Chenin Blanc and Syrah wine grape varieties.

MATERIALS AND METHODS

The experiment was conducted at the farm of ICAR-National Research Centre for Grapes Pune during 2014-15. Pune (18.32°N and 73.51°E) has tropical wet and dry climate with an average temperature ranging between 20 to 28 °C. Six-year-old vines of Chenin Blanc and Syrah grafted onto 110-R rootstock were selected for the study. The vines were planted in N-S direction with spacing of 2.66 m between the rows and 1.33 m between the vines. The vines were trained to mini-Y- trellises with single cordon trained in horizontal orientation.

The fruit pruning was done on 10^{th} September 2014. The canopy size was controlled by shoot thinning during the pre-bloom stage. The vines under each treatment were cluster thinned after berry setting (at pea size). The cluster load was

*Corresponding author's E-mail: rgsgrapes@gmail.com

controlled by retaining 40, 60 and 80 clusters/ vine respectively. The experiment was laid out in randomized block design with seven replications. Five vines were selected under each replication to record the observations. To study the effect of these treatments on growth, yield, quality, photosynthesis rate and biochemical compositions, grape bunches under each treatment were harvested on the same date. The shoot length and shoot diameter were measured at 120 days after fruit pruning. At harvest, average bunch weight, 100-berry weight and yield per vine was recorded. Hundred berry samples were randomly selected from each replicate and processed in a blender and strained through two layers of muslin cloth. Soluble solids concentration was determined from the juice using a digital refractometer (model ERMA of Japan).

Reducing sugar was estimated using dinitrosalicylic acid (DNSA) method and total carbohydrate was estimated by Anthrone method using D-glucose as the standard. Total phenol content in the fruit extract was determined using the Folin-Ciocalteu method using gallic acid as the standard. The total protein content was estimated as per the procedures of Lowry's method [12]. All biochemical parameters were estimated using UV spectrometer. The standard reference chemicals like D-glucose, 4- methyl- catechol, Bovine serum albumin etc. used were obtained from the S.D. Fine chemicals Ltd., Mumbai (India). All other buffers and chemicals were of AR grade and obtained from Merck Pvt. Ltd.

From each variety, one kg berry sample was collected randomly at the fruit maturity when the berries attained TSS between 22 to 24ºB. The collected berry sample were packed in food grade polythene bag and brought to laboratory for further analysis. The berries were then homogenized in mixer cum grinder. For extraction of the phenolic compounds, 1g of homogenized sample was drawn into 15 mL polypropylene tube containing 5 mL of 0.1% formic acid in 20% methanol. The mixture was vortexed for 1 minute followed by centrifugation at 5000 rpm for 5 minutes. One mL of supernatant was transferred to Eppendorf tube and again centrifuged at 10,000 rpm at 4ºC for 10 min. The supernatant was filtered through 0.2 µm- membrane filter (Pall life Sciences, India) and the filtrate was used for analysis.

The certified reference standards of all the test phenolic compounds and methanol (HPLC grade) were procured from Sigma Aldrich, India while other reagents obtained from Thomas Baker, Mumbai, India. The standard stock solution of each phenolic compound was prepared by dissolving 10 mg individual analyte in 10 mL methanol and stored at -20°C. An intermediate stock solution of 10 mg/L was prepared by mixing appropriate volume of each stock solution in methanol.

Chromatographic analysis of phenolic compounds was performed using 1260 series Agilent HPLC, equipped with an inbuilt 4 channel degassing unit, standard auto-sampler, 1260 infinity quaternary pump, an Agilent 1260 infinity Diode array detector and an injector. An Agilent EZ chrome elite® software was used for instrument control, data acquisition and data analysis. A Zorbax Eclipse plus C18 column (4.6 mm × 100 mm, 1.8 µm particle size was used for separation of the phenolic compounds. The mobile phase consisted of A (0.2% acetic acid in 10% acetonitrile-99%) and B (0.2% acetic acid in acetonitrile-1%) which was maintained at constant flow rate of 0.80 mL/minute. The column oven temperature was maintained at 30°C. Peaks were determined at 280 nm for all the phenolic compounds. The separation was carried out in 20 minutes under the following conditions: 0 m 99% of A; 4 m of 99% of A; 8 m of 80% of A; 10 m of 60% of A; 13 m of 60% of A; 15 m of 99% of A; 20 m of 99% of A (Fig. 1).

Gas exchange parameters such as photosynthetic rate, stomatal conductance and transpiration rates were measured using an infra-red gas analyzer (IRGA) Model, LICOR, Li 6400 Portable photosynthesis system (USA) at the stage of 8-10 mm berry size. The readings were taken in full sunlight between 10:00 and 11.30 am. The area of the chamber for holding the leaves was 6.25cm^2. The photosynthetic rate was expressed as µmol/cm^2/s, stomatal conductance in cm/s while the transpiration rate was expressed as mmol/ m^2/sec.

The grapes were harvested at 23°Brix corresponding to wines containing 11% ethanol (v/v) and processed following the traditional protocol of wine making. Berries of wine varieties were destemmed and crushed on de-stemmer-cum-crusher and transferred to 20 L stainless steel containers. Potassium metabisulphite @ 5 mg/ 10 kg grape must was added to stop the activities of naturally available microorganisms. The grape musts were exposed to cold shock at 5°C followed by pump. The must was incubated with commercial yeast strain EC1118 (*Saccharomyces bayanus)* in the form of dry active yeast (20 mg/L). The temperature for fermentation was maintained below 22 ± 2°C with cold exchanger (Frozen water container) and the fermentation process was carried out for eleven days. After fermentation (reducing sugar <2g/L), the wines were separated from the skins and seeds. After required racking and separation of lees, 60 ppm SO_2 was added and bottles were stored at 4°C until

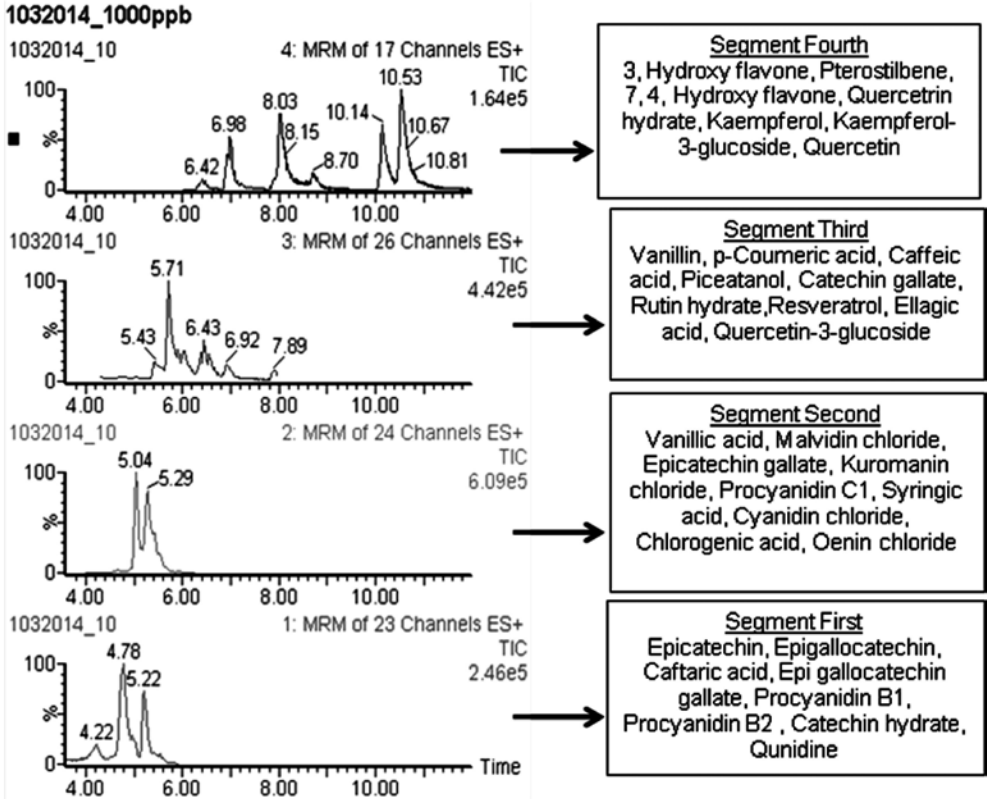

Fig. 1. Total Ion chromatograph for phenolic compounds.

analysis were carried out. From the prepared wine, phenolic compounds were tested.

The data were presented as an average for all the different characters studied. The experiment was conducted in randomized block design consisting of three treatments as different cluster load. All calculations were performed using the GLM procedure of SAS System software, version 9.3.

RESULTS AND DISCUSSION

The data collected on various vegetative parameters of Chenin Blanc and Syrah wine grape varieties are presented in Table 1. In Chenin Blanc, shoot length ranged from 64.03 cm (40 cluster/vine) to 57.01 cm (80 cluster/vine). Syrah variety also showed similar trend and it ranged from 58.27 cm (40 cluster/vine) to 50.61 cm (80 cluster/vine). The trend for reduction in shoot length with increase in cluster load was recorded in both the varieties. The reduction in shoot length might be due to the fact that during the cluster development, the cluster acts as a sink while the shoot acts as a source. Hence, the growing shoot could have played important role in cluster development. Similarly, the reduction in shoot growth might be due to the transportation of food material from source, the growing tip to the developing cluster resulted into the reduced shoot length. The results of the present investigation also support our earlier results in Sharad Seedless (Somkuwar *et al.*, 19).

The cluster thinning treatments did not affect shoot diameter as that of shoot length. The general decline in vegetative growth with the increase in cluster/vine was noted during the season. However, cluster thinning significantly affected cluster weight and quality like TSS and acidity. The decrease in yield above 45 bunches per vine was probably associated with limited availability of assimilates to each cluster (Naor and Gal, 13), while the wine quality did not decrease with increasing crop load (Reynolds *et al.*, 15).

Average cluster weight, 100 berry weight and yield/vine significantly varied in both the varieties. The cluster weight was increased linearly with reduction in number of clusters/vine. In Chenin Blanc, the highest cluster weight of 104.77 g was recorded when 40 clusters were retained as compared to 90.06 g with 80 clusters/vine. In Syrah variety, the cluster weight ranged from 92.25 g to 83.06 g from 40 to 80 bunches respectively. The results of the present investigation revealed that the cluster weight was reduced significantly with increase in number of clusters/vine.

Table 1. Effect of cluster load on vegetative growth and yield parameters in Chenin Blanc and Syrah wine grapes.

Clusters/ vine	Chenin Blanc					Syrah				
	Shoot Length (cm)	Shoot diameter (mm)	100-berry weight (g)	Av. Cluster weight (g)	Yield/ vine (kg)	Shoot Length (cm)	Shoot diameter (mm)	100-berry weight (g)	Av. Cluster weight (g)	Yield/ vine (kg)
40 clusters	64.06a	5.13a	119.27	104.02a	4.00c	58.27a	4.94a	94.41a	92.31a	3.16c
60 clusters	59.40b	5.11a	110.32	95.18b	5.42b	51.59b	4.91a	90.60a	88.38b	4.53b
80 clusters	57.02c	5.11a	102.71	90.20c	7.10a	50.59c	5.01a	90.42a	83.16c	6.46a
CV %	0.74	1.38	1.670	1.443	4.10	0.37	3.14	2.00	2.68	1.80
LSD 5%	0.52	0.08	2.16	1.62	0.26	0.23	0.18	2.16	2.74	0.099

Among the berry quality parameters, 100-berry weight in Chenin Blanc was reduced with increase in the cluster load. At 40 clusters, the weight was 119.55 g while it was reduced to 102.52 g at 80 clusters. Similar trend was also observed in Syrah variety where 100-berry weight decreased from 94.00 g (40 clusters/vine) to 90.66 g (80 clusters/vine). In general, the decrease in 100-berry weight was found to be associated with increase in number of clusters/vine. The reduction of berry weight could be attributed to the reduction in supply of food material from source to sink or less competition among the retained minimum number of clusters. The increase in 100-berry weight in the present study also contributed for increase in average cluster weight. In most cases, the average cluster weight was found to increase as the number of clusters/ vine decreased because of increased berry weight (Reynolds *et al.*, 15). With the increase in number of clusters/vine, the total yield per vine was also increased. The reduction in yield following cluster thinning has been previously reported in several other grape cultivars (Naor and Gal, 13). Increase in berry diameter and berry weight was associated with reduction in clusters/vine. The increase in berry diameter through reduced cluster/ vine also contributed to the increase in yield per vine via total cluster weight. Similarly, Naor and Gal (13) reported slight increase in berry weight due to cluster thinning while working on Sauvignon Blanc.

Significant differences were recorded for yield per vine. With the increase in clusters/vine, the yield per vine was also increased in both the varieties studied. The yield/vine in Chenin Blanc ranged from 3.98 kg with minimum cluster load treatment to 7.10 kg in highest clusters/vine. Removal of excess clusters immediately after the berry set had direct effect on significant reduction in yield/vine. However, retention of minimum clusters upto 40 had indirect effect on increase in average cluster weight via 100-berry weight. The yield was also doubled from minimum cluster load to the highest. It was noticed that the reduction in clusters/vine improved the fruit quality. The maximum clusters increased the yield/vine but there was reduction in fruit quality. Reduction of TSS in berries with increased cluster load was noticed in the present study. This was mainly because of increased cluster load correlated with dense canopy in 80 clusters/vine that has delayed sugar formation and more acids in grape berries as also reported by Abd El-Razek *et al*. (1) for reduction in sugar and Ristic *et al.*, (17) for increases in titratable acidity of the must.

The increase in yield per vine might be due to increase in both number of clusters/vine and number of berries per cluster. These results also confirm the findings of Fawzi *et al.* (5) who reported the increase in yield per vine due to increase in number of clusters in Crimson Seedless grapevine.

Significant differences were recorded for total soluble solids in the berries (Table 2). It was observed that, with the reduction in clusters/vine, the total soluble solid was increased. Higher amount of total soluble solids of 24.50°Brix was recorded in vines with minimum clusters compared to 18.80°B in higher clusters. The increase in TSS might be due to consequence of a shift of the source: sink ratio that allows a greater allocation of photosynthesis into remaining clusters (Lorenzo *et al*., 11). Significant reduction in TSS with the increase in cluster load in Sharad Seedless (Somkuwar *et al*., 19) and Sauvignon Blanc (Naor and Gal, 13) was also reported. With the increase in bud load from 78 to 143, the acidity was also increased from 0.45 to 0.53% in Crimson Seedless (Fawzi *et al*., 5).

The juice pH increased from 3.38 to 3.52 in Chenin Blanc when compared with minimum to higher cluster load, while in Syrah, it was less than Chenin Blanc (Table 2). However, the increase in pH was recorded in 80 cluster/vine (3.52) followed by 60 cluster/vine (3.44) in Chenin Blanc while in Syrah, it was reduced from 3.44 (80 bunches) to 3.31 in 40 and 60 clusters/vine respectively. The results of

Table 2. Effect of cluster load on quality parameters in Chenin Blanc and Syrah wine grapes.

Clusters/vine	Chenin Blanc				Syrah			
	TSS (°Brix)	pH	TA (g/L)	VA (g/L)	TSS (°Brix)	pH	TA (g/L)	VA (g/L)
40 clusters	23.45a	3.38b	6.40c	0.11	23.52a	3.31b	6.35c	0.14a
60 clusters	23.31a	3.44b	6.60b	0.11	22.50b	3.31b	6.42b	0.12b
80 clusters	21.98b	3.52a	6.82a	0.10	20.07c	3.44a	6.49a	0.11b
CV %	0.92	1.50	0.72	13.65	1.52	1.19	0.50	8.04
LSD 5%	0.24	0.06	0.05	0.01	0.39	0.06	0.04	0.011

the present investigation are in agreements with the findings of various workers where the cluster thinning improved juice composition by increasing TSS and pH but not acidity (Dami *et al.*, 4). Cluster thinning and pH relation has been explained by earlier studies in different countries.

All the gas exchange parameters varied significantly in both the varieties. In Chenin Blanc, the highest rate of photosynthesis (13.81µmol/mg/s) was recorded in 80 clusters/vine as against 10.46 µmol/mg/s in 40 clusters/vine. It was observed that photosynthetic activity increased with the increase in cluster load. Stomatal conductance ranged from 0.11 cm/s (40 clusters/vine) to 0.16 cm/s (80 clusters/vine). The increase in transpiration rate with increase in cluster load per vine was noticed in the same variety.

In Syrah, though the pattern of increase in photosynthesis was same, the rate of photosynthesis was less to that of Chenin Blanc. The photosynthesis in this variety ranged from 9.07µmol/mg/s to 10.88µmol/mg/s. The minimum rate of photosynthesis recorded in this investigation which seems triggered for stomatal closer (Table 3). Santesteban *et al.* (18) considered that thinning may have resulted in a decrease rate of photosynthesis, in view of the fact that a reduction of sink size, down regulates the leaf photosynthetic activity and water loss through transpiration. However, the differences for stomatal conductance and transpiration rate was non-significant. In the present investigation, the reduction in photosynthesis mainly correlated with reduction in cluster number.

Our results are also in agreement with Kaps and Cahoon (9) who found that photosynthesis increases in response to greater assimilates demands when the crop level of potted and field grown Seyval Blanc vine was increased. The increase in photosynthesis also improved storage in the vine with higher cluster load.

Significant difference was recorded for major biochemical parameters (Table 4). In Chenin Blanc, highest reducing sugar (328.00mg/g), proteins (11.69 mg/g) and phenols (3.74 mg/g) were recorded with 40 clusters/vine. While, higher starch (10.68 mg/g) and total carbohydrate (31.43 mg/g) was recorded under higher cluster (80) retention treatment. In Syrah, the trend for changes in biochemical parameters was different. Retention of 60 clusters/vine recorded higher reducing sugar (291.80 mg/g), protein (12.77 mg/g) and phenols (5.66 mg/g).

The differences in reducing sugar might be due to the changes in photosynthetic activities of vine. The results obtained in the present investigation also confirms earlier findings of decrease in sugar content of berries with increase in cluster load in Sharad Seedless grapes (Somkuwar *et al.*, 19) and Crimson Seedless (Fawzi *et al.* (5). The total phenol content constitutes a determinant factor in the quality of a wine as they are responsible for color, bitterness and astringency as key sensory wine attributes. The

Table 3. Effect of cluster load on gas exchange parameters in Chenin Blanc and Syrah wine grapes.

Clusters/vine	Chenin Blanc			Syrah		
	Photosynthesis (umol/cm^2/s)	Stomatal Conductance (cm/s)	Transpiration rate (mmol H_2O m^{-2}s^{-1})	Photosynthesis (umol/cm^2/s)	Stomatal Conductance (cm/s)	Transpiration rate (mmol H_2O m^{-2}s^{-1})
40 clusters	10.46c	0.11a	2.45c	9.07b	0.14	4.44a
60 clusters	12.41b	0.15a	4.16a	1082a	0.16	5.25a
80 clusters	13.81a	0.16a	3.02b	10.88a	0.16	4.92a
CV %	1.27	331.86	2.02	22.12	76.55	23.84
LSD 5%	0.18	2.00	0.07	2.52	0.16	1.28

Table 4. Effect of cluster load on fruit biochemical in Chenin Blanc and Syrah wine grapes.

Clusters/vine	Chenin Blanc			Syrah		
	Reducing Sugar (mg/g)	Protein (mg/g)	Phenols (mg/g)	Reducing Sugar (mg/g)	Protein (mg/g)	Phenols (mg/g)
40 clusters	328.00a	11.69a	3.74a	217.80b	13.39a	5.35a
60 clusters	187.40c	5.02b	2.35b	291.80a	12.77b	5.66a
80 clusters	255.37b	3.73c	2.30b	220.55	9.79c	5.05a
CV %	0.95	2.82	1.48	27.27b	24.04	27.55
LSD 5%	2.84	0.22	0.04	7.93	2.95	1.18

increases in phenolic contents in both the varieties might be due to exposure of bunches to the sunlight. Tomas and Espin (20) reported the phenolic contents of the plants depend on number of agronomic and environmental factors. Similarly, Santesteban *et al.* (18) also reported the effect of cluster thinning on total phenols in grape berries. Appropriate cluster retention treatment that have been resulted into highest active photosynthetic rate help to store more carbohydrate in a bunch. This increase in food material in the source is transported to sink (the berries). In tropical region, after fruit pruning, shoot density is maintained based on the number of bunches retained. This is mainly done to nourish the developing bunch. The increase in shoot length by decreasing number of shoots in this study might have contributed for better photosynthesis. The findings of the present study support the results of Gao and Cahoon (6) who reported that increase in leaves through shoot length leads to heavy canopy with increase in active photosynthesis and store carbohydrate in the new canes.

The increase in clusters/vine increased titratable acidity and pH (Table 5). In Chenin Blanc, titratable acid in the must increased from 5.50 to 5.79 g/L and pH from 3.45 to 3.55 from lower to higher cluster load. The same trend was also observed in Syrah; however, the concentration was lower than Chenin Blanc. TA increased from 4.25 to 5.40 g/L and pH from 3.49 to 3.65. The minimum cluster load recorded low titratable acidity (5.5 g/L) and pH 3.45 in Chenin Blanc. Bravdo *et al.* (3) reported improved wine quality with reduced crop load. The minor differences for ethanol content were found in both the varieties. Malic acid content of must was significantly affected by cluster load treatments in both the varieties. It ranged from 2.20 g/L (40 clusters/vine) to 2.6 g/L (80 clusters/vine) in Syrah. The concentration of malic acid in must of Chenin Blanc was higher than Syrah and was ranged from 4.30 g/L to 4.60 g/L. This indicated that, lower cluster load influenced the low acids content while the higher cluster load maintained the acids content slightly higher. The cluster load also had marked effect on concentration of volatile acid of must in both the varieties. The volatile acid concentration was increased from 0.32 g/L with 40 cluster/vine to 0.42 g/L in 80 clusters/vine in Chenin Blanc. The cluster load in the present study showed as a dominant factor in yield and quality of wine grapes.

Among the varieties, total phenolic content was higher in Syrah compared to Chenin Blanc (Table 6). In the wine made from Chenin Blanc and Syrah variety, the concentration of phenolic compounds decreased with the increase in cluster load. Among the different phenolic groups, the concentration of total anthocyanin was higher in 40 clusters/vine in Chenin Blanc (175.62 ppm) while total flavonols and flavonlalgycons were minimum (10.92 ppm). In the same variety at 80 bunches, total anthocyanin was 125.65 ppm followed

Table 5. Effect of cluster load on must quality in Chenin Blanc and Syrah wine grapes.

Clusters/vine	Chenin Blanc					Syrah				
	TA (g/L)	pH	Ethanol %	Malic acid (g/L)	VA (g/L)	TA	pH	Ethanol %	Malic acid (g/L)	VA (g/L)
40 clusters	5.50b	3.45c	11.71c	4.29b	0.32b	4.25c	3.49c	12.91b	2.19b	0.23b
60 clusters	5.30c	3.53b	12.30a	4.30b	0.34b	4.50b	3.55b	13.46a	2.30b	0.24b
80 clusters	5.79a	3.55a	12.02b	4.60a	0.42a	5.40a	3.65a	13.46a	2.59a	0.34a
CV %	1.76	0.49	1.02	1.24	3.45	2.26	0.77	0.78	0.98	4.82
LSD 5%	0.11	0.02	0.14	0.06	0.01	0.11	0.02	0.14	0.06	0.014

Table 6. Effect of cluster load on phenolic composition of wine made from Chenin Blanc and Syrah wine grapes.

Phenolic composition (ppm) 40 clusters		Chenin Blanc			Syrah		
		60 clusters	80 clusters	40 clusters	60 clusters	80 clusters	
Flavan-3-ols	Catechin Hydrate	11.023	9.805	8.725	31.23	25.805	22.725
	Epicatechin	1.967	1.748	1.859	1.967	1.748	1.859
	Total Flavan-3-ols	12.99	11.553	10.584	33.19	27.553	24.584
Flavonols and Flavonlalgycons	Qucertin Hydrate	11.763	9.315	8.023	19.763	13.315	12.023
	Rutin Hydrate	4.73	2.302	1.432	14.34	9.584	7.486
	Myricitin	1.73	1.21	0.98	3.041	2.018	0.967
	Kampherol	2.7	1.84	1.07	4.407	3.337	2. 497
	Total Flavonols and Flavonlalgycons	10.923	14.667	11.505	41.558	28.254	20.476
Hydroxybenzoic acid	Gallic Acid	1.84	1.67	0.98	2.98	2.57	2.11
	Ellagic Acid	8.238	5.958	4.116	11.124	9.568	7.216
	Vanillic Acid	0.732	0.42	0.263	1.63	1.043	0.897
	Sorbic Acid	0.453	0.292	0.178	0.574	0.39	0.192
	Total hydroxybenxzoic acid	11.263	8.34	5.537	16.308	13.571	10.415
Hydroxycinnamic acid	Caftaric Acid	3.78	2.53	2.29	8.97	5.92	4.14
	P-Caumaric Acid	1.576	1.023	0.843	2.07	1.61	0.954
	Chlorogenic acid	1.873	0.942	0.689	1.65	1.03	0.871
	Total Hydroxycinnamic acid	7.229	4.495	3.822	12.69	8.56	5.965
Stilbenes	Picetannol	19.82	17.45	15.93	27.34	21.99	18.36
	Resveratrol	0.47	0.28	0.11	0.32	0.22	0.19
	Total Stilbenes	20.29	17.73	16.04	27.66	22.21	18.55
Anthocyanin	Cynadin	10.97	8.23	7..33	19.89	14.05	10.43
	Delphinidin	6.83	5.87	3.71	49.11	42.7	37.14
	Peonidin	18.34	13.12	7.65	36.68	31.14	29.96
	Petunidin	15.92	11.6	10.45	59.23	54.16	45.76
	Malvidin	123.56	112.79	103.84	161.82	147.95	134.59
	Total Anthocyanin	175.62	151.61	125.65	326.73	290	257.88
	Total phenolics	238.315	198.395	173.138	458.136	390.148	337.87

by total stilbene (16.04 ppm), total flavonols and flavonlalgycons (11.50 ppm), total Flavan-3-ols (10.58 ppm) while the concentration of total hydroxycinnamic acid was lowest 3.82 ppm).

In Syrah, the lower clusters/vine (40 clusters) resulted in higher phenolic content (458.13 ppm) followed by 60 clusters/vine (390.14 ppm) while the increased clusters up to 80/vine resulted in lower concentration of total phenolics (337.87 ppm). Among the different compounds, total anthocyanin content was higher (326.73 ppm) at lower cluster load followed by total flavonols and flavonlalgycons (41.55 ppm), total Flavan-3-ols (33.19 ppm) while the total Hydroxy-cinnamic acid was in less concentration (12.69 ppm).

The higher concentration of phenolic compound in the lower clusters/vine treatment in the present study also supports the results of Reynolds *et al.*, (16) who reported that the vineyards with low yields have better phenolic compositions than vineyards with higher yield. In Blaufränkisch and Merlot wine the correlation between increased polyphenol content and wine quality was proven applying yield regulation in the vineyard (Kinga *et al.*, 10).

It is important for wine industry to determine the factors that affect the biosynthesis of polyphenolic compounds under prevailing conditions in the country. Prajitna *et al.* (14) stated that cluster thinning might have increased polyphenols accumulation indirectly by advancing fruit maturity or more directly by altering the source to sink balance and as such might have increased the substrate levels necessary for polyphenols synthesis.

In conclusion, a considerable variation in terms of total soluble solids, acidity and phenolic content was found among the different cluster loads in two grape varieties. In both varieties, increase in number of bunches per vine increased the yield per vine, while, the TSS was reduced. Lower cluster load recorded higher concentration of phenolics in the wine made from Chenin Blanc and Syrah varieties. The wine made from Syrah had higher total phenolics than Chenin Blanc. The fruit composition suggested the protein content was reduced with the increase in clusters/vine. The wine pH was also increased with the increase in cluster load. These varieties showed the potential for wine quality and acceptability in the wine industry.

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