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EVALUATION OF WHITE WINE VARIETIES FOR GROWTH, YIELD, BERRY AND WINE QUALITY UNDER PUNE REGION OF MAHARASHTRA, INDIA

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ABSTRACT

Nine white wine grape varieties were evaluated for growth, yield components, berry, wine quality and wine sensory parameters. The pruning weight was significantly higher in Sauvignon Blanc, while early days to bud sprout and higher number of cane/vine was observed in Gewurztraminer. The higher number of bunches/ vine and yield/vine was recorded in Chenin Blanc and Colombord, respectively. The maximum average bunch weight in Colombordand 100 berry weight was recorded in Vermentino, while number of berries/ bunch was recorded in Gros Mesang. Gewurztraminer recorded the highest total soluble solids and lowest acidity. Significantly higher juice pH and juice recovery were recorded in Viognier. Gros Mesang recorded highest wine pH while Colombordand Gewurztraminer recorded highest total acid and volatile acid. The ethanol and malic acid were maximum in Chenin Blanc as compared to other cultivars. Organoleptic test done for overall wine quality in which 5-point hedonic scale was used. Aromatic intensity, sweetness, acidity, body and overall quality was better with Chenin Blanc. Colour and alcohol were better in Vermentino. These results signify the high potential of Pune region for growing wine varieties with further efforts to improve the quality.

Key words : Wine grape varieties, growth, yield, quality, growing degree days

Introduction

The grape (*Vitis vinifera*) belong to family Vitaceae, which consist 12 genera and 600 species, genus Vitis consist 60 species. The grape is grown in relatively temperate climates and well adapted to sub-tropical and tropical areas. The grape is deciduous and perennial crop. The grape was one of the first fruit crop cultivated by human to produce table fruits, dry fruits, juice, and wine preparation (Fredrique*et al.*, 2010). The grape is one of the world's most widely grown fruit as the history of grape cultivation is as old as that of man. Grape is unique fruit, not only a major global horticultural crop but also is one of the oldest fruits. Worldwide grapes are mainly utilized for winemaking followed by table purpose and raisin making. World wine production, excluding juices and musts, in 2020 was estimated at 260 million hectolitres. Winemaking was concentrated mainly in EU countries. Other than these countries, China, US, Australia, Argentina, South Africa, and major wine producing countries. Italy is a leading country in winemaking production with a volume of 49.1 million hectolitres followed by France and Spain with volume of 46.6 and 40.7 million hectolitres, respectively (OIV, 2021).

Presently, grape is grown in India over an area of 1.62 lakh ha with production of 34.45 lakh MT and productivity of 21.00 MT/ha. The major grape growing states in India are Maharashtra (70.67%), Karnataka (24.49%), Andhra Pradesh (1.34%), Tamil Nadu (1.43%), Madhya Pradesh (1.02%) and Mizoram (0.50%) amounting to nearly 90 percent of the total production (Anonymous, 2022).

Wine is the fermented product known to the mankind since the time of civilization. The wine production in India is negligible due to limited domestic consumption and non-availability of standard wine varieties to produce good quality wine of international standards. Most of the commercial grapes grown in our country are table varieties, when used for wine making, result in poor quality production of wine because of varieties suitable for wine making have specific characteristics to make sure quality of wine. Different agro-climatic conditions can impact the performance of a particular variety and may not perform similar under another set of agro-climatic conditions. Wine contains complex product have volatile compounds, which is responsible for unique flavour. The flavour composition of wine is based on the variety and ripeness of the grape, climate and soil conditions, and wine making technique. These factors affects wine quality and flavour of wine (Thorngate, 1997). Considering these, a study on performance of white wine grape varieties under Pune condition was conducted.

Materials and Methods

The present study was conducted at the experimental farm of ICAR-National Research Centre for Grapes, Pune ($18^0$32'N and $73^0$51'E) during 2015-16 and 2016-17. Four-year-old vines of nine different white wine grape varieties (Viognier, Vermentino, Gros Mesang, Chenin Blanc, Muscat White, Sauvignon Blanc, Riesling, Gewurztraminer and Colombord) were selected for the study. The vines were trained onto mini-Y, system of trellises spaced at 2.4×1.2 m thus accommodating about 3400 vines per hectare. In an annual growth period, the vines are pruned twice i.e. first pruning is done during April (foundation pruning) while the second pruning in October (forward pruning).

Growth, yield and quality parameters

Pruned biomass were weighed after forward pruning for selected vines and average was calculated. Days taken for bud sprouting were recorded from the date of pruning to sprouting of bud. The first sprouted bud with fully expanded leaf was considered as the reference point for calculating the duration of sprouting. The number of canes per vine was counted at cane maturity and mean was recorded. The weight of five healthy bunches per replication was recorded during harvesting using a weighing balance to calculate the average bunch weight (g). The total number of berries were counted from selected five bunches in each treatment and mean number of berries per bunch was calculated. Hundred berries selected from five separate bunches weighted by using weighing balance and hundred berry weight was recorded and expressed in gram. Five vines were selected in each replication per treatment to calculate number of bunches per vine and yield per vine and was expressed in kg.

Harvesting was done about 140 days after forward pruning during the month of March. Atharvest, soluble solids (Brix), titratable acidity (g L^{-1} tartaric acid) and pH were measured using the juice of pressed berries (100 berries per treatment) collected. Solublesolids (ºBrix) were determined using a hand held refractometer (ERMA, Japan) with temperature compensated to 20ºC. The pH of pure juice of each sample was determined using a pH meter. Titratable acidity was determined by titration with 0.1 N NaOH to a phenolphthaleinend point and expressed as g L^{-1}(Ryan and Dupont, 1973). Juice recovery (%) was measured by crushing 1 kg grape berries. To measure volatile acid (g/l), titration method (0.1 N NaOH) using phenolphthalein indicator was used.

Wine preparation and Analysis for Wine Quality parameters

The wine was prepared using standard protocol. Bunches from each variety were harvested after attaining the total soluble solids of around 23^0Brix. The separated berries were crushed using a Destemmer-cum-crusher and subsequently juice transferred into 20L stainless steel containers. To stop the activity of naturally occurring micro-organisms, potassium meta-bisulphite (KMS) was added (5mg/10 kg grape must). The prepared grape must was then exposed to cold shock at 5^0C and the must was incubated with commercial yeast strain EC1118 (*Saccharomyces bayanus*) at 20 mg/L in the activated form. During the fermentation period, the temperature was maintained below 22 ± 2^0C with cold exchanger (Frozen water container). It took 11 days to reach sugar level less than 2g/L. Wine made from each variety was separated from container and as soon as the racking and lees separation were completed, 60 ppm SO_2 was added and the bottles were kept in storage at 4^0C for further analysis. The wine quality parameters (pH, ethanol, malic acid, and volatile acid) were recorded on a FTIR based analyser called Oeno Foss. The wine sample were drowned into falcon tube and centrifuged at 500 rpm for 5 minutes and the readings were recorded.

Growing Degree Days

Heat units, expressed in growing degree-days (GDD), are frequently used to describe the timing of biological processes.

The basic equation used is GDD = [(T MAX + T MIN) 2]-T BASE, where T_{MAX} and T_{MIN} are daily maximum and minimum air temperature, respectively, and T_{BASE} is the base temperature.

Wine Sensory Evaluation

Wine sensory evaluation was done by serving the wine samples to panel comprising 20 individuals. For organoleptic test, 5-point hedonic scale score card contains various wine quality parameters like colour, aromatic intensity, sweetness, acidity, tannin, body, alcohol, length, and overall quality (Cuarto and Magsino, 2017).

Statistical analysis

The experiment was laid out in Randomized Block Design (RBD), replicated three times. Data were subjected to statistical analysis as per method given by Panse and Sukhatme (1985).

Results and Discussion

Growth and Yield parameters

The results obtained in the present study revealed that maximum pruning weight was recorded in Sauvignon Blanc (0.93 kg), while the minimum was registered in Viognier (0.51 kg). The difference in the pruning weight among the varieties may be attributed to the difference in the vigour of vine resulting from assimilation of carbohydrates due to a greater number of canes, number of leaves produced and other growth parameters results in more dry matter production. High pruning weight can be attributed to high number of canes per vine as recorded in this experiment. Temperature also plays a major role in pruning weight along with genetic factors (Satisha and Shikhamany, 1999). Gewurztraminer recorded an early bud sprouting (8.17 days), while in GrosMesang delayed bud sprouting was observed (16.36 days). Bud burst is a varietal character as it marks the beginning of seasonal growth and it is strongly influenced by temperature. The data on the parameter clearly indicated that prevailing temperature after pruning affects the time required for bud break in the same variety and the influence of temperature is more than that of variety. Italia at Hyderabad took more than 15 days for bud break and at Venezuela another tropical country, took less than 12 days for bud break (Pina and Bautista, 2006). The highest number of canes/vine was also registered in the variety Gewurztraminer (32.84) and least in Viognier (15.52). The count of canes per vine serves as the base for determining the vine vigour which in turn influences the production of both fruiting and renewal spurs. These differences in the number of canes may be due to the differences in vigour which might be due to genotypes expression of the varieties (Ratnacharyulu, 2010).

The data recorded on yield attributing parameters are presented in the Table 1. The variation in yield parameters (bunches/vine, bunch weight, etc.) was recorded in all the varieties studied. The number of bunches/vine was maximum in Chenin Blanc (44.06) and minimum in Gros Mesang (6.21). There was a notable correlation between bunch characteristics and fruit yield. The quantity of bunches/vine shows significant variation based on the variety, vine nutrition, and the potential growing site. The productivity of bunches, bunch weight and length appear to be a genetic phenomenon, but the climate and soil nutrient status also contribute to certain extent. This difference in the number of bunches/vine may be attributed to varietal character due to a greater number of canes or immaturity of canes in different varieties. Similar line of work in grapes was reported by Somkuwar *et al.*, (2020). The maximum bunch weight was recorded in Colombord (195.23 g) followed by Vermentino (168.07 g) while, minimum number of bunch weight was observed in Riesling (54.26 g). The higher yield was recorded in Colombord (5.91 kg) while the minimum yield was recorded in Gros Mesang (0.78 kg). Disparities in yield/vine among various grape cultivars may be attributed to variations in bunch weight, number of bunches, and berry weight and age of the vines besides their successful adoption to the varying agro-climatic conditions under which they are cultivated (Havinal *et al.*, 2008). The positive correlation of yield/vine with average bunch weight and berry weight was recorded. Crop yield was found to increase in proportion to the number of clusters/vine, a trend similarly observed in the findings of Myers *et al.* (2008) in Sangiovese grapevine. Somkuwar *et al*. (2010) reported that Sauvignon Blanc grape crop increased proportionally with the number of clusters upto 44 per vine. The maximum number of berries/bunch was recorded in Gros Mesang (127.22). The minimum number of berries/bunch was recorded in Riesling (71.59). The variation in berry weight may arise from differences in both the diameter of the berries and the number of berries/bunch (Thakur *et al.*, 2008). A decrease in the number of berries/bunch can lead to an increase in both the length and diameter of the berries, attributed to the more effective utilization of nutrients for fruiting. The reduction of berry weight in Tempranillo may be due to competition for metabolites with greater number of berries/bunch. Vermentino recorded maximum 100-berry-weight (210.54 g), followed by Colombord (172.70 g). Minimum 100-berry-weight was recorded in Riesling (78.89 g). The variation in berry weight might be due to the difference in diameter and length of grape berries as was reported by Richard *et al.* (1999). The variety GrosMesang had recorded higher number of seeds/berry (3.1) followed by Riesling (2.8) while lowest (2.1 each) was recorded in Colombord, Chenin Blanc and Viognier.

Berry Quality parameters

Based on mean of two years data, it was concluded that maximum TSS was recorded in Gewurztraminer (23.92^0B) which was at par with Riesling (23.77^0B) and

Table 1 : Evaluation of white wine grape varieties for growth and yield parameters.

Variety	Pruning weight (kg)			Days to sprout			Number of canes/vine			Number of bunches/vine		
	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
Viognier	0.51	0.52	0.51	8.03	9.00	8.52	15.03	16.00	15.52	26.19	27.00	26.60
Vermentino	0.63	0.66	0.65	15.03	16.10	15.57	20.29	21.25	20.77	17.79	18.90	18.35
Gross Mesang	0.58	0.58	0.58	15.71	17.00	16.36	20.71	21.73	21.22	5.91	6.50	6.21
Chenin Blanc	0.74	0.77	0.75	8.71	9.80	9.26	31.71	32.57	32.14	43.51	44.60	44.06
Muscat White	0.52	0.53	0.53	10.03	11.20	10.62	25.71	26.80	26.26	21.93	22.60	22.27
Sauvignon Blanc	0.91	0.95	0.93	13.03	14.60	13.82	22.03	21.03	21.53	26.93	27.00	26.97
Riesling	0.77	0.81	0.79	12.71	13.42	13.07	16.29	17.41	16.85	30.69	31.85	31.27
Gewurztraminer	0.58	0.62	0.60	7.71	8.63	8.17	32.25	33.43	32.84	27.63	28.60	28.12
Colombord	0.65	0.66	0.66	8.71	9.45	9.08	21.03	22.33	21.68	30.01	30.25	30.13
SEm±	0.01	0.01	0.01	0.24	0.26	0.25	0.46	0.46	0.46	0.49	0.49	0.49
CD 5%	0.03	0.03	0.03	0.72	0.36	0.74	1.36	1.38	1.37	1.46	1.46	1.46
Sig	**	**	**	**	**	**	**	**	**	**	**	**

Variety	Average bunch weight (g)			Yield/vine (kg)			100 berry weight (g)			Number of berries/bunch			No of seed/berry		
	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
Viognier	78.29	79.45	78.87	2.06	2.16	2.11	85.71	86.00	85.86	93.29	94.45	93.87	2.0	2.2	2.1
Vermentino	167.29	168.85	168.07	3.00	3.21	3.10	210.03	211.04	210.54	73.03	74.05	73.54	2.7	2.8	2.7
Gross Mesang	124.71	125.75	125.23	0.74	0.83	0.78	96.71	97.80	97.26	126.71	127.72	127.22	3.0	3.2	3.1
Chenin Blanc	120.03	121.10	120.57	5.25	5.42	5.33	103.03	104.11	103.57	121.71	122.80	122.26	2.0	2.3	2.1
Muscat White	104.71	105.75	105.23	2.32	2.41	2.36	119.03	120.25	119.64	87.29	88.45	87.87	2.3	2.7	2.5
Sauvignon Blanc	106.71	107.70	107.21	2.90	2.93	2.91	94.03	95.12	94.58	119.03	120.50	119.77	2.3	2.7	2.5
Riesling	53.71	54.80	54.26	1.66	1.76	1.71	78.29	79.50	78.89	71.03	72.14	71.59	2.7	2.9	2.8
Gewurztraminer	64.71	65.75	65.23	1.81	1.90	1.85	85.03	86.69	85.86	73.29	74.63	73.96	2.3	2.5	2.4
Colombord	194.71	195.75	195.23	5.87	5.95	5.91	172.03	176.37	172.70	107.03	108.10	107.57	2.0	2.2	2.1
SEm±	2.38	2.39	2.39	1.43	0.14	0.14	2.46	2.47	2.47	1.61	1.62	1.61	0.05	0.04	0.04
CD 5%	7.15	7.16	7.15	0.43	0.43	0.43	7.39	7.40	7.39	2.28	4.85	4.84	0.16	0.12	0.13
Sig	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

* = Significant at P< 0.05, ** = Significant at P < 0.01, NS = Non significant.

Table 2 : Evaluation of white wine grape varieties for quality parameters.

Variety	TSS (^{0}B)			Acidity (g/l)			Juice pH			Volatile acidity (g/l)		
	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
Viognier	23.13	23.50	23.32	6.00	6.10	6.05	3.72	3.57	3.65	0.07	0.06	0.07
Vermentino	23.13	23.20	23.17	6.27	6.40	6.34	3.48	3.54	3.51	0.07	0.08	0.08
Gross Mesang	22.40	23.57	22.99	6.37	6.51	6.44	3.01	3.46	3.24	0.08	0.07	0.08
Chenin Blanc	23.51	23.70	23.61	6.20	6.35	6.28	3.38	3.54	3.46	0.06	0.07	0.07
Muscat White	23.20	23.60	23.40	6.67	6.70	6.69	3.65	3.36	3.51	0.10	0.20	0.15
Sauvignon Blanc	22.70	23.53	23.12	6.05	6.19	6.12	3.67	3.25	3.46	0.10	0.20	0.15
Riesling	24.04	23.50	23.77	6.65	6.81	6.73	3.64	3.42	3.53	0.10	0.20	0.15
Gewurztraminer	24.03	23.80	23.92	6.76	6.80	6.78	3.51	3.49	3.50	0.06	0.07	0.07
Colombord	23.03	23.27	23.15	6.70	6.84	6.77	3.48	3.56	3.52	0.07	0.06	0.07
SEm±	0.21	0.22	0.21	0.06	0.06	0.06	0.03	0.03	3.03	0.001	0.004	0.003
CD 5%	0.62	0.66	0.64	0.19	0.19	0.19	0.09	0.09	0.09	0.004	0.012	0.008
Sig	**	NS	NS	**	**	**	**	**	**	**	**	**

Variety	Juice recovery (%)		
	2015-16	2016-17	Mean
Viognier	62.00	63.00	62.50
Vermentino	57.00	59.00	58.00
Gross Mesang	56.00	55.00	55.50
Chenin Blanc	58.00	60.00	59.00
Muscat White	57.00	58.00	57.50
Sauvignon Blanc	60.00	62.00	61.00
Riesling	54.00	56.00	55.00
Gewurztraminer	58.00	61.00	59.50
Colombord	58.00	61.00	59.50
SEm ±	0.53	0.52	0.52
CD 5%	1.58	1.57	1.57
Sig	**	**	**

*= Significant at $P< 0.05$, **= Significant at $P < 0.01$, NS = Non significant.

Chenin Blanc (23.61 ^{0}B), while the minimum TSS was recorded in GrosMesang (22.99 ^{0}B). The lowest acidity was recorded in Gewurztraminer (6.05 g/l) which was at par with Riesling (6.12 g/l), while the highest acidity was recorded in Gros Mesang (6.78 g/l). As TSS increased, the acidity in juice decreased. These results are also in agreement with Somkuwar *et al.*, (2019a). The biochemicals (SSC, TA, sugars, amino acids, organic acids, phenolic compounds and total antioxidants) attributes of table grapes varieties can vary with change in the site, locality, topography and environment. Similar observation was also reported by Khan *et al.*, (2011). The highest juice pH was recorded in Viognier (3.65), followed by Riesling (3.53) and Colombord (3.52), while the least was in Gros Mesang (3.24). The variation in juice pH might be because of varietal difference since all the varieties were grown under the identical condition and the harvesting was also done at appropriate sugar level. The volatile acids in grape berries were higher in Riesling, Sauvignon Blanc, and Muscat White (0.15 g/l each respectively) while lower concentration in Calombord, Gewurztraminer, Chenin Blanc and Viognier (0.7 g/l each respectively). The maximum juice recovery was recorded in Viognier (62.50 %) while minimum was observed in Riesling (55.00 %). For good wine stability, upper limit of pH for red wine should be 3.5 (Morris *et al.*, 1984). Suresh and Negi (1975) reported a pH range of 3.1-3.7 in the must of thirty grape wine varieties studied. The similar trends were also obtained by Somkuwar *et al.*, (2019b).

Wine Quality parameters

The data recorded on quality parameters in the different wine varieties are presented in Table 3. Total acid was significantly higher in wine made from Colombord (6.40 g/l) which was closely followed by Chenin Blanc (5.90 g/l) while, lowest in Gewurztraminer (3.50 g/l). The wine made from Colombord recorded lowest pH (3.11) and was at par with Vermentino (3.12) while the variety Gros Mesang recorded higher pH of (3.59). Pan *et al.*, (2011) reported that pH value regulates the degradation of glucose and fructose as lower the pH value, slow will be the degradation. It is also playing a modulating role in wine haze formation, which diminishes or overthrows the commercial value of wine (Lambri *et al.*, 2013). The wine made from Chenin Blanc variety recorded higher concentration of ethanol (11.55 %) which was at par with Gros Mesang (11.25 %), Muscat White (11.23 %) and Gewurztraminer (11.20 %) while the lower quantity of ethanol was recorded in Vermentino (10.32

Table 3 : Evaluation of wine quality parameters in different white wine varieties.

Variety	Total acid (g/l)			pH			Ethanol %			Malic acid (g/l)		
	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
Viognier	3.70	3.50	3.60	3.48	3.55	3.52	10.50	10.60	10.55	2.00	2.10	2.05
Vermentino	4.60	4.80	4.70	3.07	3.16	3.12	10.30	10.35	10.32	2.30	2.35	2.33
Gross Mesang	3.80	3.60	3.70	3.55	3.63	3.59	11.20	11.30	11.25	2.45	2.50	2.47
Chenin Blanc	5.80	6.00	5.90	3.49	3.56	3.53	11.50	11.60	11.55	4.30	4.35	4.33
Muscat White	3.60	3.80	3.70	3.41	3.48	3.45	13.90	13.80	13.85	2.00	2.20	2.10
Sauvignon Blanc	4.70	4.50	4.60	3.22	3.29	3.26	12.50	12.55	12.52	2.80	2.90	2.85
Riesling	4.50	4.70	4.60	3.23	3.30	3.27	12.70	12.80	12.75	1.90	2.00	1.95
Gewurztraminer	3.60	3.40	3.50	3.48	3.55	3.52	13.60	13.65	13.63	2.70	2.80	2.75
Colombord	6.30	6.50	6.40	3.06	3.16	3.11	12.60	12.10	12.35	3.20	3.30	3.25
SEm±	0.03	0.06	0.03	0.04	0.04	0.04	0.15	0.15	0.15	0.04	0.04	0.04
CD 5%	0.10	0.11	0.10	0.11	0.11	0.11	0.47	0.46	0.46	0.11	0.11	0.11
Sig	**	**	**	**	**	**	**	**	**	**	**	**

Variety	Volatile acid (g/l)		
	2015-16	2016-17	Mean
Viognier	0.22	0.25	0.23
Vermentino	0.31	0.35	0.33
Gross Mesang	0.32	0.37	0.35
Chenin Blanc	0.40	0.44	0.42
Muscat White	0.21	0.23	0.22
Sauvignon Blanc	0.18	0.21	0.20
Riesling	0.21	0.24	0.23
Gewurztraminer	0.42	0.47	0.45
Colombord	0.26	0.31	0.29
SEm ±	0.007	0.007	0.007
CD 5%	0.021	0.021	0.020
Sig	**	**	**

*= Significant at P< 0.05, **= Significant at P < 0.01, NS = Non significant.

%). The concentration of ethanol (10-14 %) was a fundamental requirement for the wine quality as it is linked to sugar content of grape berries, which affect the overall flavour of wine (Meillon*et al.,* 2010). However, it decreases the astringency and increases the bitterness of wine (Fontoin *et al.*, 2008). Malic acid concentration was higher in wine made from Chenin Blanc (4.33 g/l) followed by Colombord (3.25 g/l) while it was less in Riesling (1.95 g/l). During the wine making process, malic acid influences fermentation. Bova *et al*., (2016) reported that at high concentration of malic acid, all strains of Saccharomyces yeasts were positive that enhanced the rate of fermentation process consuming all the sugar. Van Leeuw *et al.,* (2014) reported the variation due to influence of grape cultivar on the taste and colour of wine. Zeravik*et al.,* (2016) reported role of regional factors for the malic acid concentration in wine. The concentration of volatile acid was higher in wine made from Gewurztraminer (0.45 g/l) followed by Chenin Blanc (0.42 g/l) while the variety Sauvignon Blanc (0.20 g/l) recorded least volatile acid. Volatile acid plays an important role in fermentation process as its improper fermentation processes occurring during winemaking (Mateo *et al.,* 2014) while acid, ethanol and tannins are the primary factor determine the wine aroma, taste and mouth feel in red wine (Scott *et al.,* 2017).

Correlation matrix of growing degree days with physiological growth and berry quality

To study the relationship between degree days requirement with physiological growth and berry quality traits among the varieties, a correlation analysis was carried out (Table 4). Pruning weight showed a positive correlation with days to sprout (0.279) and yield per vine (0.250). This suggests that heavier pruning might be associated with a slight increase in the days required for sprouting and potentially higher yields. A notable negative correlation is observed between pruning weight and growing degree days (-0.590), indicating that vines with heavier pruning weights might require fewer growing degree days, which could be due to a more vigorous growth response post-pruning. There is a moderate negative correlation between days to sprout and TSS (-0.538) and juice pH (-0.613), indicating that vines that sprout earlier tend to have higher TSS and lower juice pH. Days to sprout also shows a negative correlation with yield per vine (-0.320), suggesting that faster-sprouting vines might be less productive in terms of yield. Average bunch weight has a strong positive correlation

Table 4: Simple correlation among growing degree days with physiological growth and quality variable utilized for the studied wine cultivars

Parameters	**Pruning weight (g)**	**Days to sprout**	**Average bunch weight (g)**	**Yield/ vine (kg)**	**TSS (°B)**	**Acidity (g/l)**	**Juice (g) pH**	**Growing degree days**
Pruning weight (g)	1							
Days to sprout	0.279	1						
Average bunch weight (g)	-0.021	0.197	1					
Yield/vine (kg)	0.250	-0.320	0.709	1				
TSS (°B)	0.024	-0.538	-0.669	-0.123	1			
Acidity (g/l)	0.123	0.547	0.728	0.219	-0.974	1		
Juice pH	-0.109	-0.613	-0.200	0.252	0.359	-0.382	1	
Growing degree days	-0.590	-0.019	0.614	0.364	-0.516	0.402	-0.069	1

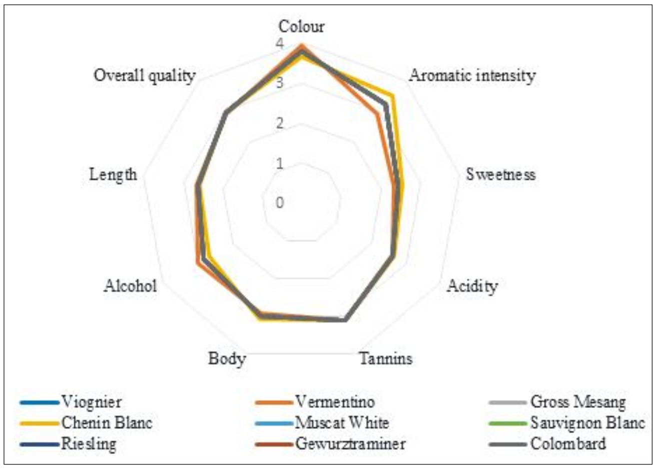

Fig. 1 : Organoleptic test of wine prepared from different White wine varieties.

with yield per vine (0.709), which is expected as heavier bunches would naturally contribute to higher yield. Yield per vine had a positive correlation with juice pH (0.252). This suggested that higher yields may be associated with larger bunches and a slight increase in juice pH. TSS showed a moderate negative correlation with average bunch weight (-0.669), indicating that larger bunches might have lower sugar content. There is also a strong negative correlation between TSS and acidity (-0.974), suggesting that higher sugar content in the grapes is associated with lower acidity levels. Acidity has a moderate positive correlation with average bunch weight (0.728). This indicated that higher acidity is related to lower sugar content and larger bunches. Acidity also showed a moderate positive correlation with days to sprout (0.547), suggesting that higher acidity might be associated with slower sprouting. Growing degree days have a strong negative correlation with TSS (-0.516), indicating that vines with lower growing degree days tend to have heavier pruning weights and higher sugar content in the grapes. There is a moderate positive correlation between growing degree days and average bunch weight (0.614) and yield per vine (0.364), suggesting that more growing degree days of suitable temperatures are associated with larger bunches and higher yields.

Wine Sensory parameters

The sensory properties of wine are affected by various parameters like colour, aromatic intensity, sweetness, acidity, tannins, body, alcohol, length and overall quality (Fig. 1). Wine made from Chenin Blanc variety had lighter colour, higher aromatic intensity of alcohol and higher sweetness. The better alcohol and length found in wine made from berries of Vermentino. The overall quality score of wine ranged from 2.97 to 2.93. The maximum score for overall quality was recorded for Chenin Blanc (2.97), while lowest overall quality was recorded in Vermentino (2.93). Teixeira *et al*. (2013) reported that molecules of phenolic compounds are responsible for the colour, aromas, and flavour of the grapes; consequently, they have a significant impact on the structural properties and sensorial qualities of grapes and, especially astringency in wines. As the sensory parameters are influenced by concentration of various biochemicals in juice, so matrix of grape berries plays a vital role. Organic acids have influence on the organoleptic properties such as flavour, taste, and colour of grape derivatives (Rizzon and Meneguzzo, 2007; Sharma *et al.*, 2018).

The present results concluded that different grape varieties observed significant differences with respect to their quantitative as well as qualitative attributes. The pruning weight was highest in Sauvignon Blanc. The maximum number of bunches/vine and yield/vine were recorded in Chenin Blanc and Colombord. The highest average bunch weight in Colombord and 100 berry weight was recorded in Vermentino, while number of berries/ bunch was recorded in Gros Mesang. Berry quality i.e.

TSS was better and acidity was lowest in Gewurztraminer, while juice pH and juice recovery were higher with Viognier. Wine parameters like wine pH was higher in GrosMesang; total acid and volatile acid was higher in Colombord and Gewurztraminer varieties. Organoleptic test done for wine; overall quality of wine found better in Chenin Blanc. Hence, considering overall wine parameters, Chenin Blanc was found better than other varieties.

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References

Anonymous (2022). *Area and production of Horticulture Crops: All India* (National Horticultural Board).

Bova, B., Nadai C., Vendramini C., Lemos Junior W.J.F., Carlot M., Skelin A., Giacomini A. and Corich V. (2016). Aptitude of Saccharomyces yeasts to ferment unripe grapes harvested during cluster thinning for reducing alcohol content of wine. *Int. J. Food Microbiol.,* **236**, 56-64. https://doi.org/10.1016/j.ijfoodmicro.2016.07.022

Cuarto, P.M. andMagsino R.F. (2017). Development of young coconut (*Cocos nucifera*) wine. *Asia Pac. J. Multidisc. Res*., **5(2)**, 89-93.

Fredrique, P., Stephanies H., Ximena M., Gerard B., Dominique F., Patricio H. and Didier M. (2010). An extensive study of the genetic diversity within seven French wine grape variety collections. *Theoret. Appl. Gen*., **120**, 1219-1231. DOI 10.1007/s00122-009-1250-8

Fontoin, H., Saucier C., Teissedre P.L. and Glories Y. (2008). Effect of pH, ethanol and acidity on astringency and bitterness of grape seed tannin oligomers in model wine solution. *Food Qual Prefer*., **19(3)**, 286-291. https://doi.org/10.1016/j.foodqual.2007.08.004

Havinal, M.N., Tambe T.B. and Patil S.P. (2008). Comparative studies on vine vigour and fruitfulness of grape wine varieties. *Asian J Hort.,* **3(1)**, 180-182.

Khan, A.S., Ahmad N., Malik A.U., Saleem B.A. and Rajwana I.A. (2011). Phenophysiological revelation of grapes germplasm grown in Faisalabad, Pakistan. *Int J Agric Biol*., **13**, 791-795.

Koyama, R., Borges W.F.S., Colombo R.C., Hussain I., Souza R.T.D. and Roberto S.R. (2020). Phenology and yield of the hybrid seedless grape 'BRS melodia' grown in an annual double cropping system in a subtropical area. *Horticulturae*, **6(1)**, 3. https://doi.org/10.3390/horticulturae6010003

Lambri, M., Dordoni R., Giribaldi M., Violetta M.R. and Giruffrida M.G. (2013). Effect of pH on the protein profile and heat stability of an Italian white wine. *Food Res. Int.*, **54(2)**, 1781-1786. https://doi.org/10.1016/j.foodres.2013.09.038

Mateo, E., Torija M.J., Mas A. and Bartowsky E.J. (2014). Acetic acid bacteria isolated from grapes of South Australian vineyards. *Int. J. Food Microbiol.*, **178**, 98-106. https://doi.org/10.1016/j.ijfoodmicro.2014.03.010

Meillon, S., Urbano C., Guillot G. and Schlich P. (2010). Acceptability of partially dealcoholized wines measuring the impact of sensory and information cues on overall liking in real life settings. *Food Qual Prefer.*, **21(7)**, 763-773. https://doi.org/10.1016/j.foodqual.2010.07.013

Myers, J.K., Wolpert J.A. and Howell G.S. (2008). Effect of shoot number on the leaf area and crop weight relationship of young Sangiovese grapewines. *Amer. J Enol Vitic*., **59(4)**, 422-424. DOI: 10.5344/ajev.2008.59.4.422

OIV (2021). State of the world vitivinicultural sector 2020. https://www.oiv.int/js/lib/pdfjs/web/viewer.html?file=/public/medias/7909/oivstate-of-the-world-vitivinicultural-sector-in-2020.pd

Pan, W., Jussier D., Terrade N., Yada R.Y. and deOrduna R.M. (2011). Kinetics of sugars, organic acids and acetaldehyde during simultaneous yeast-bacterial fermentations of white wine at different pH values. *Food Res. Int*., **44(3)**, 660-663. https://doi.org/10.1016/j.foodres.2010.09.041

Panes, V.S. and Sukhatme P.V. (1985). *Statistical methods for Agricultural Workers* (4th Edn.), ICAR, Publication, New Delhi, pp. 115-130.

Pina, S. and Bautista D. (2006). Evaluation of vegetative growth on several table grape cultivars under semiarid tropic conditions in Venezuela. *Rev Fac Agron*., **23**, 402-413.

Ratnacharyulu, S.V. (2010). Evaluation of coloured grapes varieties for yield, juice recovery and quality. *M.Sc. Thesis*. Grapes Research Station, Andhra Pradesh Horticultural University, Rajendranagar, Hyderabad, A. P.

Ryan, J.J. and Dupont J.A. (1973). Identification and analysis of major acids fom fruit juices and wines. *J. Agr. Food Chem*., **21(1)**, 45-49.

Richard, C., Ewart A. and Furkaliev J. (1999). The viticultural and morphological evaluation of Arinarnoa, Arriloba and Barbera. *Aus. Grapes Grower Wine Maker* 60-64.

Rizzon, L.A. and Meneguzzo J. (2007). *Suco de uva*, 1st edn. Embrapa Technological Information, Brasilia.

Satisha, J. and Shikhamany S.D. (1999). *Annual Report*. National Research Centre for Grapes, Pune, pp.8.

Scott, C.F., Harbertsonb J.F. and Heymanna H. (2017). A full factorial study on the effect of tannins, acidity and ethanol on the temporal perception of taste and mouthfeel in red wine. *Food Quality and Preference*, **62**, 1-7. https://doi.org/10.1016/j.foodqual.2017.05.010

Sharma, A.K., Somkuwar R.G., Bhange M.A. and Samarth R.R. (2018). Evaluation of grape varieties for juice quality under tropical condition of Pune region. *Proc Natl Acad Sci India : Sect B Biol Sci*., **88(4)**, 1517:1521. https://doi.org/10.1007/s40011-017-0894-4

Somkuwar, R.G., Ramteke S.D. and Satisha J. (2010). Effect of cluster clipping and berry thinning on yield and quality of Thompson Seedless grapes. *Acta Hort*., **758**, 229-231. https:/

/doi.org/10.17660/ActaHortic.2008.785.29

Somkuwar, R.G., Naik S., Sharma A.K. and Bhange M.A. (2019a). Performance of grape varieties grown under tropical regions for raisin yield and quality. *Indian J Hort*., **76(2)**, 355-357. http://dx.doi.org/10.5958/0974-0112.2019.00056.2

Somkuwar, R.G., Hakale D.P. and Sharma A.K. (2019b). Studies on biochemical composition of different parts of berries and wine quality of wine grape varieties (*Vitis vinifera* L.). *Int J Curr Microbiol App Sci*., **8(3)**, 155-164. https://doi.org/10.20546/ijcmas.2019.803.022

Somkuwar, R.G., Kad S., Naik S., Sharma A.K., Bhange M.A. and Bhongale A.K. (2020). Study on quality parameters of grape (*Vitis vinifera*) and raisins affected by grape type. *Indian J. Agricult. Sci*., **90(6)**, 1072-1075. https://doi.org/10.56093/ijas.v90i6.104765

Suresh, E.R. and Negi S.S. (1975). Evaluation of some grape varieties for wine quality. *J Food Sci. Techn*., **12(12)**, 79-80.

Thakur, A., Arora N.K. and Singh S.P. (2008). Evaluation of some grape varieties in the Arid Irrigated region of North West India. *Acta Hort*., **785**, 79-83.

Thorngate, J.H. (1997). The physiology of human sensory to wine: A review. *Amer. J. Enol. Viticult*., **48**, 271-279. DOI: 10.5344/ajev.1997.48.3.271

Teixeira, A., Eiras-Dias J., Castellarin S.D. and Geros H. (2013). Berry Phenolics of Grapevine under Challenging Environments. *Int. J. Mole. Sci*., **14**, 18711-18739. https://doi.org/10.3390/ijms140918711

Van Leeuw, R., Kevers C., Pincemail J., Defraigne J.O. and Dommes J. (2014). Antioxidant capacity and phenolic composition of red wines from various grape varieties: Specificity of Pinot Noir. *J. Food Composition and Analysis* **36**, 40-50. https://doi.org/10.1016/j.jfca.2014.07.001

Zeravik, J., Fohlerova Z., Milovanovic M., Kubesa O., Zeisbergerova M., Lacina K., Petrovic A., Glatz Z. and Skladal R. (2016). Various instrumental approaches for determination of organic acids in wines. *Food Chem*., **194**, 432-440. https://doi.org/10.1016/j.foodchem.2015.08.013