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Performance of red wine varieties under Pune region of Maharashtra

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Abstract
The experiment was carried out for three at the farm of ICAR- National Research Centre for Grapes, Pune. The experiment was conducted in randomized block design with three replications. The vines were trained on 'mini-Y' trellis system and spacing of 2.4×3 m^2. Four-year-old vines of these varieties were selected for the study. The growth parameters like pruning weight and shoot diameter was recorded in variety Cabernet Sauvignon and Syrah while Niellucio observed highest leaf area and shoot length. The early days to bud sprout and days to harvest was recorded in variety Cabernet Franc and Grenache. The number of bunches/vine and yield/vine were varied significantly among the varieties with number of bunches/vine and yield/vine highest in variety Syrah. But bunch weight and number of berries/bunch was highest in variety Tempranillo. However, different varieties of grape exhibited significant variation with respect to average hundred berries weight. The hundred berries weight was highest in Cinsaut. The varieties Grenache gave the highest total soluble solids and lowest acidity in Tempranillo while maximum juice recovery was observed in variety Cinsaut. Volatile acid and total acid content highest was recorded from variety Grenache and Cabernet Sauvignon as compared to other cultivars. In wine quality parameters, variety Tempranillo recorded highest wine pH while Petit Verdot and Cabernet Franc showed highest malic acid and volatile acid.

Keywords: Wine varieties, growth, yield, quality, degree days

Introduction

Grapes (*Vitis vinifera* L.) is one of the most important fruit crops of the world, it belongs to family Vitaceae includes 12 genera and about 600 species. The most important genus of economic importance is Vitis form which maximum cultivated grapes belong. Genus Vitis includes about sixty species of which *Vitis vinifera* is the most important one contributing to about 90% of the world's grapes. About 90% grapes produced are freshly consumed in India.

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) [3]. However, only about 2% of the total production of grapes is being used for juice and wine purpose (Ausari *et al*., 2024) [4].

Wine is one of the most popular beverages prepared from grapes through fermentation under the controlled conditions. It comprises phenolic compounds mainly classified into flavonoids and non-flavonoids (Garrido and Borges, 2013) [7]. These compounds are considered to have antioxidant, anti-cancer and anti-inflammatory properties (Arranz *et al.*, 2012; Casas *et al.*, 2012) [2, 6] and they are also responsible for some of the sensory attributes such as colour, flavour, aroma, bitterness and astringency in grapes and wine (Del Rio *et al.*, 2013) [7].

Wine grapes belong to the species *Vitis vinifera*, but are grown primarily for wine production. Quality wines can only be produced from quality grapes. Fruit juice and wine are categorized as "new age beverages". Historically, India is not known for its wine consumption. The Indian wine industry has experienced consistent growth over the last ten years (Vijaya *et al.*, 2018) [39]. Limited domestic consumption of wine and nonavailability of standard wine varieties to produce good quality of wine of international standards, much emphasis was not given for research on wine production in India (Shikhamany, 2001) [31].

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Considering this red wine grape varieties were evaluated for growth, yield and wine quality under Pune condition of Maharashtra, India.

Materials and Methods

Vineyard, Experiment Design, and Vine Management

The experiment was carried out during three years (2014-15, 2015-16 and 2016-17) in an experimental vineyard located at ICAR-National Research Centre for Grapes, Pune, India (18.32° N latitude, 73.51° E longitude and 559 m altitude). Ten red wine varieties i.e., Syrah, Cinsaut, Caladoc, Grenache Noir, Niellucio, Tempranillo, Petit Verdot, Merlot Cabernet Franc and Cabernet Sauvignon were evaluated in a randomized Block design with three replicates represented by five vines per replication. The plants were four years old, trained onto mini-Y, system of trellises and spacing 2.4×1.2 m accommodating about 3400 vines per hectare.
The soil of this region is black having pH 7.75 and EC 0.46 dS/m. However, water used for irrigation had EC 1.8 and pH 8.3 (Somkuwar *et. al.*, 2019a) [34]. Planting of grapevine was done in North-South direction. In an annual growth period, the vines were pruned twice i.e. first pruning is done during April (Foundation pruning) while the second pruning in October (forward pruning) remaining 4-5 buds. 25 shoots per vine were maintained for yield.

Growth, yield and quality parameters

Pruned biomass were measured after forward pruning for selected vines and average was calculated. The shoot length was measured by using measuring tape and shoot diameter was measured by a Vernier calliper. Leaf area was measured using portable leaf area meter (model CI- 203, USA). Days taken for 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. Days to version and days to harvest was calculated from date of fruit pruning for individual vines.
Harvesting was done about 145 days after forward pruning during the month of March. At harvest, soluble solids (Brix), treatable acidity (g L^{-1} tartaric acid) and pH were measured using the juice of pressed berries (100 berries per treatment) collected. Soluble solids (ºBrix) were determined using a handheld refractometer (ERMA, Japan) with temperature compensated to 20ºC. The pH of pure juice of every sample was determined using a pH meter. Treatable acidity was determined by titration with 0.1 N NaOH to a phenolphthalein end point and expressed as g L^{-1} (Ryan and Dupont, 1973) [28]. Juice recovery (%) was recorded by crushing 1 kg grape berries. The observations on the number of berries/bunches, 100 berry weight (g), average bunch weight, days taken for harvest and yield per vine were recorded at the harvesting stage.

Wine preparation and analysis for quality parameters

The wine was prepared using standard protocol. Bunches from each variety were harvested after attaining the total soluble solids of around 23 ºBrix. The separated berries were crushed using a Destemmer-cum-crusher and subsequently transferred into 20L stainless steel containers. To stop the activity of naturally occurring micro-organisms, potassium meta-bisulphite (KMS) was added. The prepared grape must was then exposed to cold shock at 5 ºC for 24 hrs. After that must was incubated with commercial yeast strain EC1118 (*Saccharomyces bayanus*) at 20 mg/L in the form of dry active yeast. During the fermentation process, temperature of 22 ± 2 ºC was maintained with cold exchanger (Frozen water container). Fermentation was stopped by adding KMS (5mg/10 kg grape must). Wine prepared from each variety when sugar level of wine per kg available, separated skins and seeds manually. As soon as the racking and less separation were completed, 60 ppm SO_2 was maintained 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 by Oeno Foss (FTIR based wine analyser). The wine samples were drowned into falcon tube and centrifuged at 500 rpm for 5 minutes and the readings were recorded. The experiment was laid out in Randomized Block Design (RBD), and it was replicated three times. Data were subjected to statistical analysis as per method given by Panse and Sukhatme (1985) [25].

Results and Discussion

Growth parameters

The comparison of ten grape varieties for different growth parameters has been presented in Table 1. Significant variation was observed with respect to the pruning weight among the varieties between the years. The pooled data signifies that among the varieties evaluated, Cabernet Sauvignon has recorded highest pruning weight (1.48 kg/vine) closely followed by cv. Shirah (0.86 kg/vine) while, Lowest pruning weight was recorded by cv. Petit Verdot (0.25 kg/vine). When the individual years are considered, during the first year of study (2014-15), highest pruning weight was recorded by the variety Cabernet Sauvignon (1.55 kg/vine) followed by Merlot (0.84 kg/vine) while least weight was observed with Petit Verdot (0.20 kg/vine). Similar trend was noticed during the second year of study.
In the year 2016-17, highest pruning weight was recorded in Syrah (1.37 kg/vine) which was at par with cultivar Grenache (1.35 kg/vine) while, lowest pruning weight was showed in Petit Verdot (0.40 kg/vine). The vigour of vine is expressed in terms of pruning weight and this character is an important growth attribute for distinguishing different grape varieties as vigorous and non-vigorous based on growth rate (Benz *et al.*, 2006) [5]. The amount of pruning weight depends upon the vigour of the vine highly vigorous vines produce more pruning weight than less and medium vigorous varieties. 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. Similar significant variation for pruning weight was found by (Jayalakshmi *et al.*, 2019) [13].
The grand mean value (mean over three years) revealed significant differences in leaf area and shoot length of wine varieties of grapes (Table 1). Among wine varieties significantly highest mean leaf area was found in cv. Niellucio (170.73 cm^2 and 92.93 mm) followed by Petit Verdot (161.00 cm^2) in leaf area and Syrah and Cabernet Sauvignon (83.93 and 83.63 mm) in shoot length. The shoot diameter was maximum in cv. Syrah (6.54 mm) which was at par with Caladoc (6.42 mm) and the lowest shoot diameter was recorded in cv. Cabernet Franc (5.13 mm). Shoot growth is strongly influenced by temperature, soil moisture, grapevine nutrient and reserve status, pruning

level, plant age or genetic characteristics of the rootstock or scion (Keller, 2015) [17]. Vigorous varieties have produced shorter shoots than less vigorous varieties due to number of buds retained on the cane after pruning (Veena *et al.*, 2015) [38]. Genotypes having less number of leaves have recorded higher leaf area and vice versa which might be due to translocation of more photosynthates to the leaf growth which ultimately resulted in higher leaf area (Jayalakshmi *et al.*, 2019) [13].

Table 1: Performance of wine grapes (*Vitis vinifera* L.). Varieties on growth attributes

Variety	Pruning weight (kg)				Leaf area (cm^2)				Shoot length (mm)				Shoot diameter (mm)			
	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean
Syrah	0.60	0.62	1.37	0.86	135.00	134.00	136.00	135.00	81.20	84.50	86.10	83.93	6.51	6.50	6.60	6.54
Cinsaut	0.60	0.61	1.29	0.83	145.10	146.20	145.00	145.43	67.20	70.50	72.20	69.97	6.10	6.20	6.20	6.17
Caladoc	0.78	0.88	0.86	0.84	146.20	146.00	146.50	146.23	66.10	66.00	67.20	66.43	6.45	6.40	6.42	6.42
Grenache	0.20	0.15	1.35	0.57	120.20	120.63	122.00	120.94	37.20	39.20	45.50	40.63	5.60	5.60	5.65	5.62
Niellucio	0.75	0.82	0.76	0.78	170.20	170.00	172.00	170.73	90.70	95.00	93.10	92.93	6.20	6.15	6.20	6.18
Tempranillo	0.74	0.77	0.55	0.69	156.20	160.00	162.00	159.40	62.20	63.25	63.00	62.82	6.40	6.42	6.45	6.42
Petit Verdot	0.20	0.15	0.40	0.25	162.20	162.00	158.80	161.00	39.50	42.61	42.10	41.40	6.00	6.10	6.10	6.07
Merlot	0.84	0.88	0.80	0.84	150.50	152.80	152.00	151.77	53.40	54.50	55.57	54.49	5.61	5.60	5.62	5.61
C. Franc	0.42	0.39	0.41	0.41	145.00	148.20	150.10	147.77	60.70	62.80	64.00	62.50	5.00	5.20	5.20	5.13
C. Sauvignon	1.55	1.58	1.30	1.48	130.20	132.80	133.00	132.00	83.60	83.00	84.30	83.63	5.00	5.50	5.60	5.37
S.Em±	0.01	0.01	0.01	0.16	1.34	1.16	1.13	0.84	0.98	0.62	0.58	0.84	0.54	0.66	0.51	0.06
CD 5%	0.03	0.02	0.02	0.46	3.98	3.45	3.37	2.50	2.90	1.84	1.72	2.50	1.62	1.97	1.52	0.17
Sig	**	**	**	**	**	**	**	**	**	**	**	**	NS	NS	NS	**

*=significant at $p<0.05$, **=significant at $p<0.01$, NS=Non-Significant

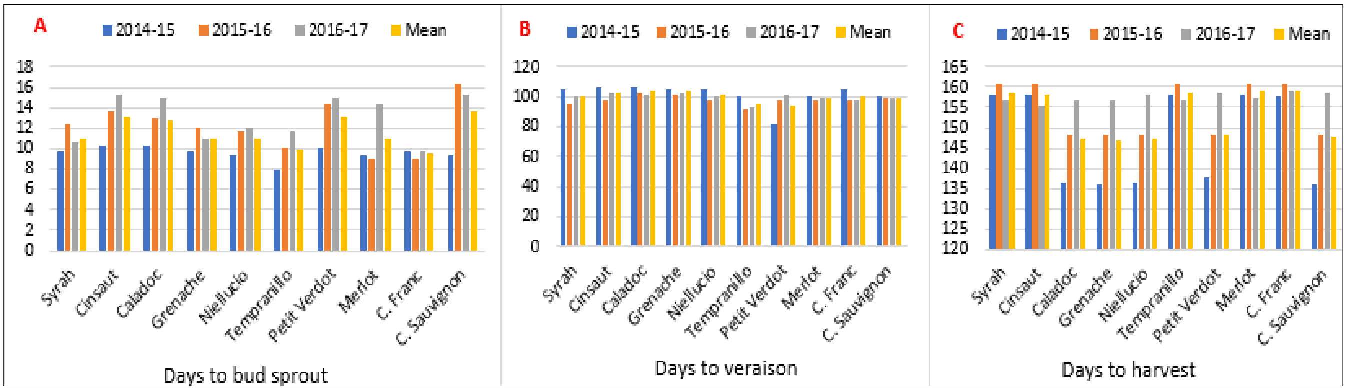

Fig 1: Performance of wine grapes (*Vitis vinifera* L.). varieties on growth A. Days to bud sprout, B. Days to veraison, C. Days to harvest.

Days to bud sprout, days to veraison and days to harvest were significantly influenced by varieties (Fig 1). Days to bud sprout was significantly minimum was showed in cv. Cabernet Blanc (9.45) which was at par with the cv. Tempranillo, Grenache and Merlot. However, maximum days to bud sprout in cv. Cabernet Sauvignon (13.66). The pooled data reveal that the days to veraison was found non-significant. With respect to the years, days to veraison was minimum in Petit Verdot (81.33) in the first year of experiment than that of second year in cv. Tempranillo (91.67). During the first year, maximum days to veraison was observed in the cv. Cinsaut (106.33). In the second year of study (2015-16), Caladoc recorded maximum days to veraison (95.33). During 2016-17, minimum days to veraison was recorded in Tempranillo (93.00) while, maximum days to veraison was observed in Cinsaut and Grenache (103.33). The perusal of pooled data indicates that irrespective of the years, the varieties exhibited significant differences of the days to harvest. The minimum days to harvest was observed in Grenache (147.00) closely followed by Caladoc (147.11), Niellucio (147.44) and Cabernet Sauvignon (147.56) while, maximum days to harvest was recorded in cv. Cabernet Franc (159.22). Bud sprouting is a genotypic character and it is strongly influenced by temperature. Days taken for bud sprouting varies from genotype to genotype and climatic conditions. Similar studies were reported by Huang and Lu (2000) [12].

Yield parameters

Average bunch weight, number of bunches per vine, number of berries per bunch, total yield of vine and 100 berry weight were significantly influenced by varieties (Table 2). The highest average bunch weight was observed in Cinsaut (110.70 and 182.00 g) for the year 2014-15 and 2015-16 whereas, in 2016-17 and pooled mean it was higher on Tempranillo (237.67 and 156.12 g) variety, respectively while, during the year 2014-15 the lowest average bunch weight was recorded cv. Caladoc and Petit Verdot (63.20 g). In the year 2015-16, 2016-17 also pooled mean the maximum average bunch weight was observed in Merlot (65.00, 47.00 and 70.10 g respectively). The variation in the bunch weight among different varieties may be attributed to inherent genetic character of the variety, number of berries per bunch, difference in number of canes and berry size and also the size of vine canopy where varieties with larger canopy sizes were noted to have higher bunch weights. (Walker *et al.*, 2000; Havinal *et al.*, 2008) [40, 11].

The mean number of bunches per vine was maximum in Syrah (48.67) followed by Caladoc (39.11), Cabernet Sauvignon (38.67). While minimum number of bunches was found in variety Merlot (13.00). 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 per vine may be attributed to varietal character due to more number of canes or immaturity of canes in different varieties. Similar line of work in grapes was reported by Havinal (2007) [10] and Somkuwar *et al*., (2020) [35].

The maximum number of berries/bunch were recorded in Cabernet Sauvignon (111.00) during the year 2014-15 whereas, in 2016-17 and pooled mean it was maximum in Cinsaut (227.33 and 134.55) and in 2015-16 was recorded maximum in Niellucio (145.00) variety. While minimum number of berries/bunch were recorded in Merlot (69.00 and 79.00 respectively) during both the year 2015-16 and 2016-17 while, in 2014-15 and pooled data was recorded in Niellucio and Cabernet Franc (62.33 and 81.55). The maximum 100 berry weight was exhibited in Cinsaut (130.00 g) whereas it was minimum in Cabernet Sauvignon (130.68 g). The higher yield/vine was recorded in Syrah (4.85, 11.19 and 6.89 kg) variety while lower yield was recorded on Petit Verdot (0.46 kg) during 2014-15. Merlot variety was observed in (1.28, 0.14 and 1.01 kg), respectively in 2015-16, 2016-17 and pooled mean. The differences in berry weight may arise from variations in berry diameter as well as the number of berries per bunch (Thakur *et al.,* 2008) [37]. The reduction of berry weight in Tempranillo may be due to competition for metabolites with greater number of berries per bunch. These results are in agreement with the findings of and Kadu *et al.* (2007) [14] and Ratnacharyulu (2010) [27]. Genetic constitution of individual vines and the local climatic conditions also influence the variation in yield. The difference in the yield per vine across various grape cultivars might be due to variations in bunch weight, weight of the berries, number of bunches and age of the vines besides their successful adoption to the varying agro-climatic conditions under which they are cultivated (Havinal *et al.*, 2008) [11]. Similar line of work is reported by Al-Obeed *et al.* (2010) [1]; Somkuwar *et al*. (2008) [32]; Khan *et al*. (2011) [16]; Veena *et al*. (2015) [38]; Vijaya *et al*. (2018) [39].

Table 2: Performance of wine grapes (*Vitis vinifera* L.). varieties on yield attributes

Variety	Average bunch weight (g)				Number of bunches/vine				Number of berries/bunch				Yield/vine (Kg)			
	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean
Syrah	110.30	124.00	173.00	135.77	44.00	37.33	64.67	48.67	97.00	103.67	111.67	104.11	4.85	4.63	11.19	6.89
Cinsaut	110.70	182.00	132.33	141.68	10.00	46.67	4.33	20.33	75.33	125.00	134.67	111.67	1.11	8.49	0.57	3.39
Caladoc	63.20	120.67	197.67	127.18	33.33	65.00	19.00	39.11	67.33	109.00	227.33	134.55	2.11	7.84	3.75	4.57
Grenache	99.20	105.00	194.00	132.73	14.00	44.33	30.67	29.67	73.00	99.33	206.00	126.11	1.39	4.65	5.95	4.00
Niellucio	63.80	155.67	213.67	144.38	13.00	44.67	16.00	24.56	62.33	134.67	127.33	108.11	0.83	6.95	3.42	3.73
Tempranillo	85.70	145.00	237.67	156.12	13.00	57.00	29.00	33.00	92.67	145.00	143.00	126.89	1.11	8.26	6.89	5.42
Petit Verdot	63.20	100.00	95.33	86.18	7.33	31.33	4.67	14.44	77.33	110.00	87.00	91.44	0.46	3.13	0.44	1.34
Merlot	98.30	65.00	47.00	70.10	16.33	19.67	3.00	13.00	101.67	69.00	79.00	83.22	1.61	1.28	0.14	1.01
C. Franc	76.60	77.00	107.33	86.18	20.67	26.33	28.33	25.11	76.33	70.00	98.33	81.55	1.58	2.03	3.04	2.22
C. Sauvignon	95.60	95.00	119.00	103.20	24.00	72.33	19.67	38.67	111.00	115.00	130.33	118.78	2.29	6.87	2.34	3.83
S.Em±	0.80	0.59	0.51	18.18	0.58	0.41	0.40	6.65	2.51	1.95	1.73	11.41	0.06	0.06	0.06	0.94
CD 5%	2.37	1.74	1.52	54.02	1.72	1.22	1.19	19.76	7.45	5.79	5.13	33.90	0.18	0.18	0.17	2.79
Sig	**	**	**	*	**	**	**	*	**	**	**	*	**	**	**	**

Variety	100 berry weight (g)			
	2014-15	2015-16	2016-17	Mean
Syrah	50.70	110.00	144.33	101.68
Cinsaut	132.00	161.00	97.00	130.00
Caladoc	60.00	110.67	88.00	86.22
Grenache	57.00	106.00	100.33	87.78
Niellucio	54.00	118.33	155.00	109.11
Tempranillo	70.30	101.00	155.33	108.88
Petit Verdot	42.00	90.00	108.67	80.22
Merlot	44.00	94.00	58.00	65.33
C. Franc	49.30	110.00	106.67	88.66
C. Sauvignon	63.00	82.00	93.67	79.65
S.Em±	0.95	1.30	1.23	6.38
CD 5%	2.81	3.87	3.67	18.95
Sig	**	**	**	**

*=Significant at $p<0.05$, **=Significant at $p<0.01$, NS=Non Significant

Berry quality parameters

The basic fruit composition of different varieties varied for all three growing seasons. The TSS was found non-significant effect in 2015-16, 2016-17 and pooled mean, while in 2014-15 was found significant effect. The results presented in Table 3 revealed that TSS was significantly highest in Grenache (23.70ºB) and the lowest TSS was recorded in Cinsaut (18.30 ºB) during 2014-15. Juice acidity varied from 5.6-6.6 g/lit for all three years with minimum acidity in Tempranillo variety and maximum in Caladoc. As TSS increased, the acidity in juice decreased. These results are in agreement with Havinal (2007) [10], Karibasappa and Adsule (2008) [15], Somkuwar *et al*., (2019a) [34]. The highest juice pH was recorded in Tempranillo during 2014-15 and 2016-17 and in Syrah in the year 2015-16 while, the least was in Petit Verdot (2014-15), Niellucio (2015-16) and Cinsaut. (2016-17). 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 maximum juice recovery (67.00%) was recorded in Cinsaut while minimum juice recovery (56.60%) was observed in Petit Verdot. The volatile acids and total acid varied significantly differences. The volatile acids in grape berries were higher in Grenache (0.13 g/L) while Caladoc recorded lower concentration (0.10 g/L). The maximum total acid was recorded in

Cabernet Sauvignon (5.21) which was at par with Cabernet Franc and it was minimum total acid was showed in Syrah. For good wine stability, upper limit of pH for red wine should be 3.5 (Morris *et al.,* 1984) [24]. Suresh and Negi (1975) reported a pH range of 3.1-3.7 in thirty grape wine varieties in their must. The similar trends were obtained by Somkuwar *et al.,* (2019b) [34].

Table 3: Performance of wine grapes (*Vitis vinifera* L.). varieties on berry quality attribute

Variety	Acidity (g/lit)				TSS (^{0}Brix)				Juice pH				Juice recovery (%)			
	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean
Syrah	8.30	6.37	5.50	6.72	19.30	22.93	22.97	21.73	3.40	3.67	3.54	3.54	55.00	57.00	60.00	57.33
Cinsaut	8.20	6.10	5.53	6.61	18.30	22.30	22.70	21.10	3.30	3.48	3.39	3.39	68.00	65.00	68.00	67.00
Caladoc	8.60	7.67	5.33	7.20	19.20	22.50	23.00	21.57	3.20	3.48	3.46	3.38	62.60	63.00	64.00	63.20
Grenache	8.20	6.27	5.53	6.67	23.70	22.90	23.10	23.23	3.40	3.34	3.51	3.42	70.50	60.00	62.50	64.33
Niellucio	8.80	6.63	5.37	6.93	21.30	23.17	23.23	22.57	3.20	3.40	3.55	3.38	68.20	64.00	64.50	65.57
Tempranillo	6.70	6.47	5.57	6.25	22.70	23.27	23.30	23.09	3.60	3.44	3.56	3.53	65.70	58.00	60.20	61.30
Petit Verdot	7.90	5.90	5.63	6.48	20.50	23.07	23.43	22.33	3.10	3.43	3.51	3.35	55.50	56.00	58.30	56.60
Merlot	7.80	6.33	5.60	6.58	21.40	23.37	23.40	22.72	3.50	3.51	3.54	3.52	62.60	55.00	56.20	57.93
C. Franc	7.70	6.10	5.43	6.41	21.50	22.53	23.63	22.55	3.50	3.43	3.45	3.46	60.20	58.00	60.10	59.43
C. Sauvignon	7.20	6.17	5.67	6.35	23.30	23.10	23.30	23.23	3.50	3.55	3.55	3.53	65.50	65.00	66.30	65.60
S.Em±	0.06	0.05	0.06	0.26	1.01	1.21	1.81	0.56	0.01	0.01	0.01	0.06	0.63	0.35	0.44	1.42
CD 5%	0.19	0.16	0.19	0.78	3.01	3.60	5.37	1.65	0.03	0.02	0.02	0.18	1.87	1.03	1.30	4.23
Sig	**	**	*	NS	*	NS	NS	NS	**	**	**	NS	**	**	**	**

Variety	Volatile acid (g/lit)				Total acid			
	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean
Syrah	0.11	0.12	0.12	0.12	4.33	4.13	4.10	4.19
Cinsaut	0.13	0.13	0.11	0.12	4.17	4.40	4.57	4.38
Caladoc	0.10	0.10	0.10	0.10	4.93	4.80	4.87	4.87
Grenache	0.12	0.13	0.13	0.13	4.47	4.17	4.63	4.42
Niellucio	0.12	0.12	0.12	0.12	4.63	4.37	4.50	4.50
Tempranillo	0.12	0.14	0.11	0.12	3.83	4.40	4.63	4.29
Petit Verdot	0.10	0.11	0.12	0.11	4.60	4.27	4.63	4.50
Merlot	0.11	0.12	0.13	0.12	4.23	4.20	4.50	4.31
C. Franc	0.12	0.13	0.12	0.12	4.83	4.93	5.10	4.95
C. Sauvignon	0.12	0.14	0.11	0.12	5.00	5.27	5.37	5.21
S.Em±	0.01	0.01	0.01	0.01	0.04	0.05	0.04	0.11
CD 5%	0.02	0.02	0.02	0.015	0.12	0.13	0.11	0.31
Sig	*	**	*	*	**	**	**	**

*=Significant at $p<0.05$, **=Significant at $p<0.01$, NS=Non-Significant

Wine quality parameters

The data recorded on wine quality parameters in the different wine varieties are presented in Figure 2. In pooled data, which found non-significant differences between values. Wine malic acid and volatile acid found significantly higher in wine made from Petit Verdot and Cabernet Franc. While, malic acid and volatile acid recorded lowest in wine prepared from Grenache and Syrah. The non-significant contribution of tartaric acid in influencing juice pH is in accordance to findings of Kodur *et al.* (2013) [19]. But rootstocks significantly affected accumulation of malic acid in fruits of grafted scions as reported by several workers (Kodur *et al.*, 2011) [18]. Pan *et al.*, (2011) [26] conducted that pH value regulate the degradation of glucose and fructose as lower the pH value, show 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) [21]. Volatile acid plays an important role in fermentation process as its improper fermentation processes occurring during winemaking (Mateo *et al.*, 2014) [22] while acid, ethanol and tannins are the primary factor determine the wine aroma, taste and mouth feel in red wine (Scott *et al.*, 2017) [30]. The concentration of ethanol (14-16%) 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) [23]. However, it decreases astringency and increases the bitterness of wine (Fontoin *et al.*, 2008) [8].

Degree days requirement of varieties

The data on degree days and days taken for maturity are presented in Figure 3. The maximum degree days in Syrah, Cinsaut, Temperanillo, Merlot and Cabernet Franc (1871.2) degree days to maturity. While, minimum degree days required for Caladoc, Grenache, Niellucio, Cabernet Sauvignon (1571.1) and Petit Verdot (1591.8). Days required minimum for maturity was observed in Caladoc, Grenache, Niellucio and Cabernet Sauvignon (136 days) but in Syrah, Cinsaut, Temperanillo, Merlot and Cabernet Franc required maximum days to maturity (158 days). Koyama *et al.,* (2020) [20] reported that BRS Melodia grapevines required growing cycle of 138 days with a yield of 23.85 tons/ ha during the season 2013.

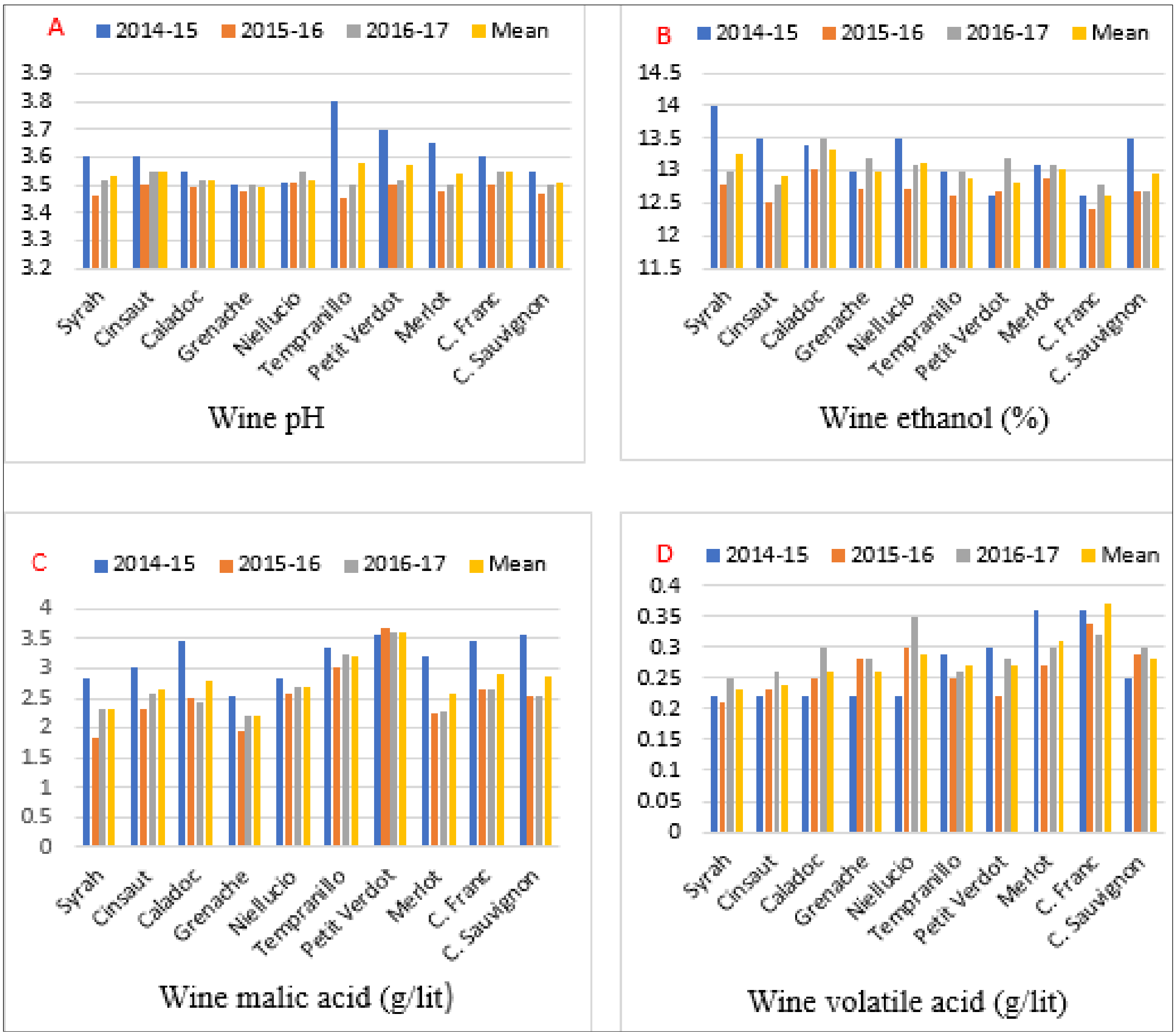

Fig 2: Performance of wine grapes (*Vitis vinifera* L.) varieties on wine quality A. wine pH, B. wine ethanol (%), C. wine malic acid, D. wine volatile acid. Means with different letters in the same column were significantly different (p<0.05).

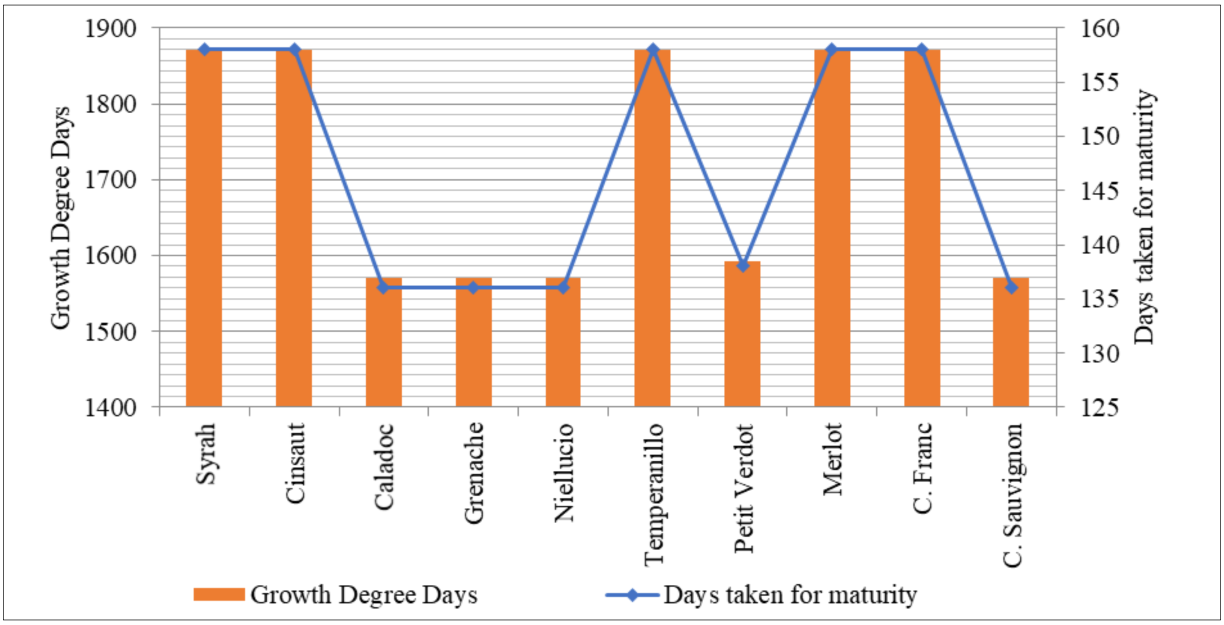

Fig 3: Degree days requirement of red wine varieties

Conclusion

The present investigation for grape varieties revealed that significant variability in relation to different growth, berry quality, wine quality and yield attributes. On the basis of research, it is concluded that, among ten grape varieties "Cabernet Sauvignon and Syrah" was found pruning weight and shoot diameter while Niellucio observed highest leaf area and shoot length. The "Tempranillo" variety, which exhibits maximum bunch weight and number of berries/bunch while number of bunches/vine and yield/vine highest in variety Syrah. Whereas, the variety "Grenache and Tempranillo" exhibited the highest total soluble solids and lowest acidity while the variety Cinsaut showed the maximum juice recovery and it is most suitable for commercial cultivation under sub-tropical region in Pune of Maharashtra. Enhancing grape productivity involves prioritizing traits from high-yielding varieties with market advantages. These varieties are recommended for future study and application in comparable environments to optimize productivity.

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