

## Effect of vineyard shading on the composition, sensory quality and volatile flavours of *Vitis vinifera* L. cv. Pinot Noir wines from mild tropics

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### Abstract

The effect of vineyard shading on the composition, sensory quality and volatile flavours of grape wines from *Vitis vinifera* L. cv. Pinot Noir under Bangalore conditions, a region endowed with mild tropical climate, was studied. Wines from 50 and 75 per cent shaded vineyards were found to have better sensory appeal, significantly higher titratable acidity and lower levels of phenolics than those from open conditions. The wine colour parameters viz., hue and chroma, were significantly superior in wines prepared from berries of open vineyards. Head space volatile analysis showed that wines from shaded vineyards possessed higher levels of Pinot Noir aroma varietal specific compounds such as phenyl ethyl alcohol, methyl anthranillate, methyl and ethyl hexanoate, linalool, octanoic acid, and decanoic acids. The study showed the possibility of improving Pinot Noir wine quality by vineyard shade management in warmer viticulture areas.

**Key words:** *Vitis vinifera*, Pinot Noir, aroma, GC MS, mesoclimate, headspace volatiles, phenolics.

### Introduction

Cultivation of wine grapes for wine production has recently become a lucrative venture in India owing to increased domestic demand and a favorable tax regime adopted by the Indian government. Area under viticulture in India are distributed predominantly in the states of Maharashtra, Karnataka and Andhra Pradesh (11° 0' - 20° 2' N and 73° 50' - 78° 0' E) among which Bangalore (12° 58' N and 77° 38' E and located 920m above MSL) enjoys a warm, salubrious climate during most part of the year characterized by a mean maximum temperature of 28-30 °C and a minimum of 17-20 °C during the berry ripening phase. Although the classic French wine cultivars like Pinot Noir, Cabernet Sauvignon and Shiraz thrive well under Indian situations, there is little information on the quality of wines produced from these varieties in India. Pinot Noir is largely considered as a temperate variety and, in warmer climates, the excess heat of the sun burns the fruit, acid becomes insufficient and the fruity aromas are lost. A number of parameters such as light, temperature, site, climate, irrigation and fertilization influence the wine quality. Wines from cooler climates are fresher, more acidic and finer in bouquet as compared to those from warmer regions which are richer in alcohol, harsher in taste and aroma. (Jackson and Lombard, 1993, Henick -Cling, 2000). Ideal conditions for improving the wine quality could be created by manipulation of mesoclimate of the vineyard using artificial structures such as shade nets and shelter belts to reduce the incidence of frost and high heat accumulation (Jackson and Lombard, 1993). In temperate regions attempts at creation of warmer mesoclimate to overcome the ill effect of freezing temperature and snowfall have proved successful in quality enhancement of wines (Reynolds *et al.*, 1996). On the

contrary, there are no studies on the possibility of improving the quality of wines from grapes grown under warmer climate. With this background, experiments were conducted to assess the quality of Pinot Noir wines, with special reference to their flavour profile, produced from vineyards in Bangalore maintained under different levels of artificially shaded conditions using shade nets..

### Materials and methods

Experiments were conducted on five-year-old grape vines of cv. Pinot Noir maintained at the vineyards of Indian Institute of Horticultural Research, Bangalore, India. Vines were grafted on Dogridge root stock and trained to overhead bower. There were twelve plants each under open and shade net treatments replicated four times in Completely Randomized Block Design (CRBD). Shade nets of two grades, that provide, 50 % and 75 % shade were drawn over the vines in order to create variable mesoclimatic conditions. Shade nets were erected at the time of back pruning and maintained until harvest. Control vines were maintained in the open conditions under full sunlight.

Red, dry table wines were prepared from the berries collected from the above treatments by the process standardized earlier (Suresh and Ethiraj, 1987). Harvested berries were washed, destemmed and sulfited with potassium metabisulphite (200 mg/L), crushed and T.S.S was adjusted to 22 °Brix with cane sugar, wherever required. The resultant must was inoculated with 48 hr old starter culture of *Saccharomyces cerevisiae* var. *ellipsoides* strain Montrachet no.522 @ 2%v/v. Fermentation was carried out at 18°C with occasional stirring of the must till completion as measured using a Brix hydrometer. The young wines were

pressed, racked, clarified using calcium bentonite (400mg/L), bottled and stored at  $10 \pm 2$  °C for aging for one year.

The biochemical characteristics of wines such as, pH, acidity, phenolics, residual sugars, volatile acidity and alcohol were analyzed as described by Caputi *et al.* (1968) and Amerine and Ough (1982). The colour properties *viz.*, hue and chroma were measured following spectrophotometric procedure (Amerine and Ough, 1982). Sensory attributes were evaluated by a panel of nine trained judges using ranking method based on Kramer's table (Kramer *et al.*, 1974).

Pinot Noir wine samples (250 mL) were flushed continuously with nitrogen at a constant flow rate of 100ml/min at  $35 \pm 2$  °C. The aroma compounds carried by nitrogen was trapped at the outlet in 250 mL ice-cold pentane: ether (1:1 v/v) mixture. The mixture was concentrated using a vacuum rotary evaporator at 25 °C to a final volume of 2 mL and dried over anhydrous sodium sulphate at 15 °C under a continuous stream of nitrogen.

GC separation of volatile components was performed using Hewlett-Packard 5890 Series-II gas chromatograph equipped with a flame ionization detector (FID). Samples were analyzed on a HP-5 column (30ml x 0.2 mm i.d., 0.5µm film thickness) with nitrogen as carrier gas at a constant flow rate of 1 mL/min and split ratio of 1:40. Temperature of column oven was programmed as follows: 60°C for 6 min, increased to 180 °C followed by a further rise from 180 to 240 °C @ 6 °C/min and finally held at 240 °C for 11 min. The temperatures of injector and detector were 270 °C and 280 °C, respectively. Retention indices (RI) were estimated in accordance with modified Kovat's method (Jennings and Shibamoto, 1980) by using hydrocarbon mixture procured from M/s Sigma Aldrich, U.S.A. Quantification of individual compounds was done based on the relative percentage of each peak against total FID peak area. Average of three runs was taken as the final value of relative peak concentration.

The volatile extracts of wine were analyzed with Varian 4000 GC-MS/MS chromatograph equipped with ion trap. The column used was DB-5 capillary column (30 m x 0.25 mm i.d., 1 µm film thickness) using helium as carrier gas at a constant flow rate of 1 mL / min and split ratio of 1:20. Temperature of the column oven was programmed as described above. Temperatures of injector, transfer line, trap and ion source were maintained at 280, 270, 210 and 220 °C, respectively. Mass spectra were recorded in EI mode at 70eV. Full scan mass spectrum was recorded with the mass ranging between 50 and 450 a.m.u. Compounds were identified based on retention indices and comparison of mass spectra with that of standard compounds available in NIST and Wiley libraries.

The data on biochemical analysis of the wine samples were

subjected to one way ANOVA for comparison of treatment means and the critical difference (CD) values were calculated (Gomez and Gomez, 1976) to determine their significance.

## Results and discussion

The highest sensory rank sum of 23 was obtained in wines made from samples grown under 75 per cent shading followed by those from 50 per cent shading (Table 1). The wines from grapes grown under open field conditions recorded the lowest sensory rank sum indicating the significant superiority of the wines from artificial shading of vineyard. These results showed the advantage of shading the vineyard for enhancement of sensory quality of wines from the continental grape variety, Pinot Noir.

Both the must and wine samples from shaded treatments had lower pH and higher total acidity as compared to open conditions (Table 1). The level of sugars in the wine samples from all the treatments was less than 0.5 per cent, a value well below the sensory threshold for sugars (0.75-1.25 %) thus indicating their dryness. The volatile acidity, which was less than 0.075 % in both open and shade treatments was also within the maximum permitted level for red table wines (Amerine and Ough, 1982). These data showed that the composition of wines in the present study with respect to sugars and volatile acidity were comparable to the prescribed standards set for wines in USA and Europe. The sensory character of wine is decided by a matrix of compounds in which the organic acids, sugars, phenolic compounds and minerals are the most common tastants eliciting sweet, sour and bitter responses (Schreier, 1979). Under warm conditions prevailing in the mild tropics, malic acid, the major organic acid present in grapes is rapidly degraded. While the poor wine quality associated with warm climates is attributable to its low acid and high pH, the increased level of organic acids under shading improve the sensory appeal which is the ultimate determinant of the quality of wine (Jackson and Lombard, 1993).

There were marked differences among treatments in the levels of total phenolics of the wines. The total concentration of phenolics in wines from open vineyards was higher (1320 mg/L) while it ranged from 1175-1225 mg/L under shade. The colour defining parameters of wine namely, hue and chroma were significantly higher in the wines from open vineyard than in shade. Studies have shown that fruit exposure to sun influences the production of phenolics in grapes and such differences may be caused due to temperature or light effects (Spayd *et al.*, 2002). Therefore, it is inferred that the observed differences in the levels of phenolics between open and shade treatments might have occurred due to differences in the exposure to light / temperature around the fruit brought out due to vineyard management. Shading of

Table 1. Effect of vineyard shading on the composition and sensory quality of pinot Noir wine

Shade (%)	Must Composition				Wine composition							
	Total acidity (% tartaric acid)	pH	T.S.S (°Brix)	pH	Total acidity (% tartaric acid)	Volatile acidity (% acetic acid)	Alcohol (%)	Phenol (mg/L)	Sugar (%)	Hue	Chroma	Sensory Rank sum
0	0.58	3.65	21.2	4.00	0.48	0.070	10.87	1320	0.24	0.496	0.976	11
50	0.75	3.50	22.0	3.70	0.60	0.045	10.98	1225	0.21	0.373	0.933	20
75	0.78	3.50	21.0	3.70	0.66	0.051	10.78	1175	0.40	0.312	0.894	23
LSD (P=0.05)	0.05	0.15	N.S.	0.20	0.04	0.010	N.S.	34	N.S.	0.05	0.06	

N.S.= Not significant; The rank totals required for significance at 5 per cent levels as per Kramer's Table is 13-23

berries in cooler climates results in unbalanced musts with low phenolics, while excessive heat in the warmer climate results in 'harsher' wines due to the presence of high levels of phenolics (Jackson and Lombard, 1993). Wine phenolics are important quality components that contribute to color, taste and feel of wines and they form stable pigmented polymers with anthocyanins giving red wine its long term color stability. The majority of phenolic constituents found in wine including tannins and anthocyanins are grape-derived. In addition to phenolics, anthocyanins also contribute to the colour characteristics of Pinot Noir wines, such as hue and chroma. Thus, the higher colour attributes in the sun exposed berries might arise from the combined effect of higher levels of tannins and anthocyanins. The optimum temperature for synthesis of anthocyanins ranges from 17 to 26°C. Generally for Pinot Noir, cool night temperatures around 15 °C promote good skin colouration in contrast to those raised at 30 °C (Price *et al.*, 1995).

The flavour profile of the wine samples as determined by GC- MS is given in Table 2. Artificial shading at both 50 % and 75 % had an influence on the total ester concentrations and relative abundance of many individual esters. The aroma impact compounds like ethyl hexanoate, decyl octanoate and methyl anthranillate were higher in shaded treatments which are likely to have contributed to the improved sensory appeal of the wines. The Pinot Noir wine aroma is known to have notes of tropical fruit flavours such as raspberry, cherry and black currant. Among the flavour compounds which impart the characteristic aroma fingerprint to Pinot Noir wines are methyl and ethyl vanillate, acetovanillone, 3-methyl 1- propanol, 3-methyl butanoic, hexanoic, octanoic and decanoic acids, 2-phenyl ethanol and benzyl alcohol. Additionally, ethyl anthranillate, ethyl cinnamate and ethyl 2, 3- hydrocinnamate have also been thought to contribute to their typical aroma while the fruity aroma is chiefly because of esters like, ethyl esters of hexanoic, benzoic, octanoic, propanoic, cinnamic, decanoic and salicylic acids along with methyl and isopropyl esters (Brander *et al.*, 1980; Moio and Etievant, 1995) . The presence of esters like, ethyl hexanoate, ethyl salicylate and methyl hexanoate among others has been reported to impart the aroma of cherry, black currant, black berry and raspberry to pinot Noir wines made from cool season grapes. Reports available in apple, olive, sweet cherry, pear, and banana show that many of the fruit aliphatic esters like, decadienoate, butanoate and hexanoate are derived from the essential fatty acid, linoleic acid (Goff and Klee, 2006). Therefore, it is possible that the differences in organic and fatty acid profiles of Pinot Noir berries arising from the shade treatments might have contributed to the formation of sweet flavoured esters. Another likely reason for the improved flavour could be better retention of these highly volatile compounds due to the low temperature in shaded conditions.

There was an increased level of the two higher alcohols, 3- methyl 1- butanol and phenyl ethyl alcohol under shading. Studies by Peirera and Gudiellere (2006) showed

Table 2. Effect of vineyard shading on the composition of head space volatiles from *Vitis vinifera* L. cv. Pinot Noir

Compound	Retention Index (RI)	Relative peak area (%)		
		Open field	50% shade	75% shade
<b>Hydrocarbons</b>				
Azulene	1312 <sup>a</sup>	1.87	1.97	1.96
Germacrane-B	1492 <sup>a</sup>	0.20	0.20	0.18
<b>Alcohols</b>				
3-Methyl-1-butanol	738 <sup>a</sup>	0.18	0.30	0.30
1-Heptyn-3-ol	885 <sup>b</sup>	0.16	0.21	0.24
2,3-Dimethyl cyclohexanol	1048 <sup>b</sup>	0.18	0.20	0.12
Phenylethyl alcohol	1125 <sup>a</sup>	0.16	0.21	0.19
2,6,6-trimethyl-2-Cyclohexene-1-methanol	1249 <sup>b</sup>	0.46	0.40	0.31
1-Phenyl-but-3-en-1-ol	1262 <sup>b</sup>	0.05	0.04	0.03
2-Butyl-1-octanol	1281 <sup>a</sup>	0.65	0.39	0.14
2-tert-butyl-p-Cresol	1358 <sup>b</sup>	0.21	0.14	0.17
Isotridecanol	1516 <sup>b</sup>	2.41	1.64	1.05
2-Hexyl-1-octanol	1611 <sup>b</sup>	0.47	0.40	0.41
4-Octylphenol	1738 <sup>b</sup>	3.91	3.97	2.93
1,2-Diphenyl-2-propanol	1783 <sup>b</sup>	0.35	0.23	0.27
2-Hexadecanol	1788 <sup>b</sup>	0.18	0.19	0.49
2-Hexyl-1-decanol	1798 <sup>b</sup>	0.31	1.07	1.03
(E)-2-Nonen-1-ol	1834 <sup>b</sup>	1.34	1.48	1.13
trans-9-Hexadecen-1-ol	1885 <sup>a</sup>	3.64	1.94	3.56
9-Heptadecanol	1889 <sup>b</sup>	5.61	8.48	7.27
1-Hexadecanol	1892 <sup>a</sup>	6.67	4.78	6.36
2-Methyl-1-hexadecanol	1898 <sup>b</sup>	1.63	1.68	1.26
1-Heptadecanol	1998 <sup>a</sup>	2.36	2.18	2.86
1-Octadecanol	2116 <sup>a</sup>	0.84	3.59	4.28
<b>Esters</b>				
Ethyl propanoate	711 <sup>a</sup>	0.03	0.05	0.04
Methyl hexanoate	915 <sup>a</sup>	0.45	0.56	0.55
Ethyl hexanoate	998 <sup>a</sup>	0.19	0.34	0.28
Hexyl acetate	1018 <sup>a</sup>	0.02	0.04	0.03
Ethyl benzoate	1168 <sup>a</sup>	0.20	0.23	0.16
Ethyl octanoate	1194 <sup>a</sup>	0.57	0.66	0.56
Ethyl Salicylate	1286 <sup>a</sup>	10.95	7.79	7.45
Hexyl valerate	1288 <sup>a</sup>	0.09	0.08	0.04
Methyl anthranilate	1329 <sup>a</sup>	0.36	0.83	0.67
Methyl benzoylformate	1338 <sup>a</sup>	0.08	0.05	0.05
Ethyl decanoate	1394 <sup>a</sup>	0.25	0.23	0.22
Ethyl cinnamate	1469 <sup>a</sup>	0.03	0.05	0.05
Decyl octanoate	1985 <sup>a</sup>	2.82	5.16	3.93
Isopropyl n-hexadecanoate	2021 <sup>a</sup>	2.12	2.64	2.60
Methyl octadecanoate	2138 <sup>a</sup>	9.15	12.64	11.06
<b>Nitrogen and sulphur compounds</b>				
Ethylphenylamine	1098 <sup>b</sup>	1.49	1.49	1.57
Diethylphenylamine	1151 <sup>a</sup>	0.11	0.21	0.92
Benzothiazole	1229 <sup>a</sup>	0.11	0.13	0.09
Cyclohexyl isothiocyanate	1256 <sup>a</sup>	1.32	1.32	1.23
Ethyl butanedithioate	1274 <sup>b</sup>	0.05	0.05	0.06
2-(methylthio)- Benzothiazole	1586 <sup>b</sup>	0.24	0.24	0.19
<b>Acids</b>				
Octanoic Acid	1182 <sup>a</sup>	0.44	0.62	0.60
Benzeneacetic acid	1284 <sup>a</sup>	0.76	0.52	1.54
Decanoic acid	1391 <sup>a</sup>	0.89	0.91	1.05
Dodecanoic acid	1588 <sup>a</sup>	0.56	0.98	1.37
Z-9 Octa decenoic acid	2007 <sup>a</sup>	2.71	1.61	4.14

a = Compound identified by comparison of mass spectra and reported R.I value;  
b = Compound identified by comparison of mass spectra only

that the pulp of shaded berries contained more phenyl alanine, the precursor of phenyl ethyl alcohol in many fruits. Under shading, there was no marked change in the concentration of total aldehydes and ketones, a group of compounds imparting characteristic aroma to wine. However, considerable differences were noted in the concentrations of dinonyl ketone, benzaldehyde and linalool. Benzaldehyde is derived from phenyl alanine in plants and is a main constituent of cherry volatiles (Goff and Klee, 2006). Linalool, contributing to floral aroma, is formed either by the degradation of free odorless polyols or hydrolysis of glycosylated conjugated forms during wine ageing. Although present in small amounts, linalool plays a significant role in contributing floral and cherry aroma to the wine due to their high Aroma Extraction Dilution Analysis (AEDA) values (Yu-Fang and Qian, 2006). In the present study, the levels of octanoic and decanoic acids were higher under artificial shade as compared to open conditions. Several acidic compounds are also known to be produced or modified during the course of yeast fermentation, which include volatile fatty acids of up to 12 carbons, primarily hexanoic, decanoic and octanoic acids *via* anabolic and catabolic pathways (Scheirer, 1979). Thus, artificial shading of vineyards was found to enhance the sensory quality and aroma of Pinot Noir wines as compared to wines made from open-grown vines possibly through subtle changes in the pathways related to metabolism of phenol and aromatic flavors during the course of fruit development and fermentation.

It is concluded that the composition, sensory attributes and flavour of wines are improved by artificial shading of vineyards when grown under mild tropical conditions. The changes brought out in acidity, levels of total phenols and profile of aroma fingerprint compounds such as individual esters, aldehydes, ketones and fatty acids contribute significantly to the overall improvement in wine quality. Future studies on further improvement of wine quality by manipulating the various cultural practices are worth exploring to obtain superior quality wines from Pinot noir grapes produced in warmer regions of the world.

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