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Effect of Protective Covering on Physicochemical Properties of Grape (*Vitis vinifera* L.)

Himatkhwah Rahimullah [1*], Wafa Sher Mohammad [1], Ehsan Qudratullah [2], and Salihi Mohammad Sadiq [2]

[1]Department of Horticulture, Faculty of Plant Sciences, Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar 3801, Afghanistan
[2]Department of Agronomy, Faculty of Plant Sciences, Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar 3801, Afghanistan
*Corresponding author email: rahimh21@gmail.com

ABSTRACT

The study was conducted at Fruit Research Farm Department of Fruit Science, Punjab Agricultural University, Ludhiana during the 2018 and 2019 fruiting seasons. The experiment was conducted on 7-year-old own-rooted vines of Perlette, Flame Seedless, Superior Seedless, and Punjab Purple grapes varieties, with spacing of 4x4 m^2 between rows and plants. The experiment consisted of 2 treatment combinations (T_1 = protective covering, T_2 = open field condition) laid out in randomized block design (RBD) with three replications. The data was analyzed for cluster weight, cluster size, total soluble solids, total sugar, acidity, TSS: acid ration, and total anthocyanins. Maximum mean cluster weight (324.7g in 2018 and 333.5g in 2019), cluster length (17cm in 2018 and 16.7cm in 2019), cluster breadth (9.5cm in 2018 and 9.3cm in 2019), TSS (18.33% in 2018 and 18.17% in 2019), total sugar (14.1% in 2018 and 13.5% in 2019), TSS/acid ratio (28.3 in 2018 and 28.4 in 2019) and total anthocyanin contents (47.95mg/100 gm pulp in 2018 and 48.77mg/100 gm pulp in 2019) were recorded in grape varieties grown under permanent protective covering, while the higher acidity (0.68% in 2018 and 0.66% in 2019) was found in grape varieties grown in open condition in both the seasons. All of these parameters, except for acidity, were minimal in grape varieties grown under open field conditions.

Keywords: Chemical characteristics, Grapes, Open filed condition, Protective covering, Physical characteristics

INTRODUCTION

Grape (*Vitis vinifera* L.) is one of the important fruit crops in the world grown commercially in temperate, tropical, and subtropical regions. Grapes are used for various purposes like wine, jam, raisins, jelly, and juice. Grape berries are attractive for their unique flavor and are utilized in many different ways. About 71 percent of the world's total production of grapes is used in preparing wine, 27 percent as fresh fruit, and 2 percent as dried fruit (FAO, 2012). The demands for grapes are increasing day by day throughout the world because of the huge potential of grapes in improving immune system of humans (Sindhu and Radhai Sri 2015).

Grape is a good source of phytochemicals which fights chronic diseases, like some kinds of cancer and cardiovascular diseases. Various studies have shown that grapes have good antioxidant activities that can inhibit cancer cell proliferation and put down platelet aggregation, and grapes also decrease cholesterol. Grapes contain different kinds of phytochemicals, like proanthocyanidins, anthocyanins, stilbenes, and phenolic acids so all of these phytochemicals act as vigorous antioxidants (Yang et al., 2009). The largest producer country of grapes is China with an annual production of 9.60 MT, followed by Italy, USA, France, and Spain. India has ranked 9th amongst major grapes-producing countries with an annual production of 2920.0 thousand tonnes from an area of 139 thousand hectares (NHB, 2018).

Protected cultivation is a unique and specialized form of agriculture. Very important factor in horticultural crop production is the climate. During the past many decades, cultivation in Rain-shelter has been studied for its commercial value on table grapes and some other fruits (Tangolar et al., 2007; Fanizza and Ricciardi 1991; Junior et al., 2011; Chavarria et al., 2011). The overall objectives of cultivation in protective covering are that, it can change and adjust the natural environment by some structures and practices to get the best productivity of crops through improving yields and product quality, expanding the area of production, and extending the effective harvest period of the product (Wittwer and Castilla, 1995).

According to some literature, rain-shelter cultivation delays grape maturation (Berli et al., 2011). Rain shelter reduces photosynthetically Active Radiation (PAR) results in the slow accumulation of sugar, increases the weight of clusters and berries of grapes, and can also improve economic returns (Tangolar et al., 2007). Several reports have shown that if grapevines are covered with plastic films, solar radiation, and PAR will be reduced (Rana et al., 2004; Conceição and Marin, 2009).

Growing vines under protected conditions is an attractive alternative for growing good quality grapes under adverse agro-climatic conditions. Even by this technique farmers can harvest grapes in the off-season or enhance the fruit quality by extending the fruit development period under protected conditions. In table grapes, a lot of potential for improvement of fruit quality exists if we extend the fruit development period /ripening period by protecting it from unseasonal rainfall and adverse climatic conditions. Hence, in present studies, commercial varieties of grapes grown under permanent protective structures were evaluated and compared with varieties grown under open field conditions.

MATERIALS AND METHODS

The present study was carried out in the Fruit Research Farm and Post Graduate Laboratory, Department of Fruit Science, Punjab Agricultural University, Ludhiana, during the 2018 and 2019 fruiting seasons. The study was carried out on 7-year-old own-rooted vines of Perlette, Flame Seedless, Superior Seedless, and Punjab Purple grapes with a spacing of 4x4 m^2 between rows and plants. The experiment consisted of 2 treatment combinations (protective covering and open condition) and was laid out in randomized block design (RBD) with three replications. The grapevines received uniform cultural practices during the study period. Fruits were harvested from all the replications at the time of ripening during morning hours. The harvested fruits were then immediately transferred to the Post Graduate Laboratory of the Department of Fruit Science for further analysis.

Experimental design and treatments

- Design = Randomized Block Design (RBD)
- Treatment 1 (T1) = Grapevines grown in permanent protecting structure
- Treatment 2 (T2) = Grapevines grown in open conditions
- No. of varieties = 04 (Perlette, Flame Seedless, Superior Seedless, and Punjab Purple)
- No. of treatments = 02
- No. of replications per treatment = 3
- No. of vines per replications = 5
- No. of experimental vines = 4 x 2 x 3 x 5 = 120

The following parameters were recorded during the study:

Cluster weight: Ten clusters from each vine of each variety were selected randomly and their weight was recorded at the time of harvest. The mean weight of these clusters was calculated.

Cluster size: Ten clusters from each vine of each variety were selected randomly and their size (length and breadth) was recorded at the time of harvest. The mean size (length and breadth) of these clusters was calculated.

Total soluble solids: Total soluble solids (TSS) were determined using a refractometer (Bausch and Lamb Hand refractometer) at room temperature.

Acidity: For determining acidity, two (2) ml of juice were titrated against 0.1 N NaOH solutions phenolphthalein was used as an indicator, and acidity was calculated.

TSS: acid ratio: For calculation of the TSS: acid ratio, the value of TSS (total soluble solids) was divided by that of the corresponding TA (titratable acidity).

Total sugars: For calculating total sugar, grape juice (10 ml) was taken in a beaker and the data was analyzed.

Anthocyanin (mg/100 g pulp): Twenty berries were taken from each replication randomly and cut into small pieces, 5 g of sample was taken, absorbance was measured at 535 nm wavelength with a spectrophotometer and the data was analyzed for total anthocyanins contents.

The data were analyzed for variance by using SAS (V 9.3, SAS Institute Inc., USA). The treatment means are subjected to mean separation by Critical Difference (LSD, $p \leq 0.05$).

RESULTS AND DISCUSSION

Cluster weight

Protective covering significantly affected cluster weight in both seasons (table 1). Maximum cluster weight (412g and 430g in 2018 and 2019, respectively) was observed in Superior Seedless grapes under protective covering which was significantly higher than open field condition. It was followed by Perlette grapes in which cluster weight was 383.2 g in 2018 and 395 g in 2019 under protective covering. The minimum cluster weight of all grape varieties was recorded under open-field conditions. Likewise, Souza *et al* (2015) stated that grapevines grown under diffused plastic showed the highest yields because of decreased rot incidence and increased cluster weight.

Cluster size

Protective covering significantly affected cluster length and breadth during both seasons (table 2). Maximum cluster length, in both seasons under a protective covering, was observed in Perlette grapes (19 cm in 2018 and 18.8 cm in 2019) statistically at par with Superior Seedless grapes. It was 17.6cm and 17.2 cm in both years under open field conditions which was lower than protective covering. Maximum cluster breadth in both seasons was observed in Superior Seedless grapes under protective covering which was significantly higher than all other varieties. In 2018, the cluster breadth of Superior Seedless grapes was recorded at 11.4 cm under protective covering and 10.5 cm under open field conditions. In 2019, its cluster breadth was 11.6 cm under protective covering and 10.2 cm under open field conditions. El-Saeed *et al.* (2015) stated that protection treatments increased bunch, size, length, and width especially plastic house which increased the yield/vine by 20 % and 7.1 % over the control.

Table 1. Effect of protective covering and open field condition on cluster weight in grapes.

Variety	Cluster Weight (g)					
	2018			2019		
	PC*	OF*	Mean	PC	OF	Mean
Perlette	383.2^{b}	370.0^{c}	376.6	395.0^{b}	380.0^{c}	387.5
Flame Seedless	376.0^{bc}	356.8^{d}	366.4	380.0^{c}	370.0^{d}	375.0
Superior Seedless	412.4^{a}	402.6^{a}	407.5	430.0^{a}	400.0^{b}	415.0
Punjab Purple	127.0^{e}	120.0^{e}	123.5	129.0^{e}	120.0^{e}	124.5
Mean	324.7	312.4	318.5	333.5	317.5	325.5
LSD $_{(p < 0.05)}$ (V)	1.98		-	6.56		-
LSD $_{(p < 0.05)}$ (C)	1.4		-	4.6		-
LSD $_{(p < 0.05)}$ (V×C)	2.8		-	9.2		-

*PC = Protective condition; *OF = Open field condition; V = Variety; C = Condition

Table 2. Effect of protective covering and open field condition on cluster size in grapes.

Variety	Cluster Size (cm)											
	2018						2019					
	Length			Breadth			Length			Breadth		
	PC*	OF*	Mean	PC	OF	Mean	PC	OF	Mean	PC	OF	Mean
Perlette	19.0^{a}	17.6^{b}	18.3	10.0^{bc}	9.5^{cd}	9.8	18.8^{a}	17.2^{a}	18	9.4^{bc}	9.2^{c}	9.3
Flame Seedless	17.9^{b}	15.0^{c}	16.5	9.2^{d}	9.6^{cd}	9.4	17.6^{a}	14.1^{b}	15.8	9.3^{bc}	9.2^{c}	9.2
Superior Seedless	18.8^{a}	18.0^{b}	18.4	11.4^{a}	10.5^{b}	10.9	18.5^{a}	17.8^{a}	18.2	11.6^{a}	10.2^{b}	10.9
Punjab Purple	12.3^{d}	12.0^{d}	12.2	7.3^{e}	6.8^{e}	7	12.0^{c}	11.4^{c}	11.7	7.0^{d}	6.5^{d}	6.7
Mean	17	15.6	16.3	9.5	9.1	9.3	16.7	15.2	15.8	9.3	8.8	9
LSD $_{(p \leq 0.05)}$ (V)	0.45		-	0.37		-	1.24		-	0.65		-
LSD $_{(p \leq 0.05)}$ (C)	0.32		-	0.26		-	0.87		-	0.46		-
LSD $_{(p \leq 0.05)}$ (V×C)	0.64		-	0.52		-	1.75		-	0.93		-

*PC = Protective condition; *OF = Open field condition; V = Variety; C = Condition

Total soluble solids

The data related to the effect of protective covering on TSS are given in Table 3 showed that maximum TSS was recorded in Punjab Purple grapes under protective covering which was 20.3% in 2018 and 19.5% in 2019 and it was higher as compared to open field condition. TSS in Punjab Purple was recorded at 19% in both seasons under open-field conditions. Likewise, El-Saeed *et al* (2015) reported that protection treatments increased the TSS of berries especially plastic houses which increased TSS (%) by 42.9 and 35.7% over the control.

Acidity

The data concerning the effect of protective covering on acidity are given in Table 4 revealing that minimum acidity (0.60% in 2018 and 0.62% in 2019) was recorded in Superior Seedless grapes grown under protective conditions. Maximum acidity (0.69% in both years) was recorded in Perlette grown under open field conditions which was higher than protective covering. Likewise, protected cultivation in peach had lower values for acidity, and higher values for pH than the open field (Furukawa *et al* 1990). Vool *et al.* (2014) reported that

titratable acid content was highest in grapes grown in open fields and lowest in grapes grown under protected conditions.

TSS: acid ratio

The perusal of data concerning the effect of protective covering on the TSS: acid ratio given in Table 5 showed that the maximum TSS: acid ratio (31.2 in 2018 and 32.5 in 2019) was recorded in Punjab Purple grapes grown under protective structure as compared to open field condition which was statistically at par with all other varieties. In open field conditions, the TSS: acid ratio in the same variety was 27.1 and 31.7 in 2018 and 2019, respectively which was lower than the protective covering. A similar study by Vool *et al.* (2014) showed that increased TSS: the acid ratio was recorded under protected conditions thus increasing the yield quality of grapes.

Table 3. Effect of protective covering and open field condition on TSS in grapes.

Variety	Total Soluble Solids (%)					
	2018			2019		
	PC*	OF*	Mean	PC	OF	Mean
Perlette	18.00^{bc}	17.10^{cd}	17.55	18.00^{bc}	17.40^{c}	17.7
Flame Seedless	18.50^{b}	18.00^{bc}	18.25	19.00^{ab}	18.60^{ab}	18.8
Superior Seedless	16.50^{d}	15.80^{d}	16.15	16.20^{d}	15.60^{d}	15.9
Punjab Purple	20.30^{a}	19.00^{b}	19.65	19.50^{a}	19.00^{a}	19.25
Mean	18.33	17.47	17.9	18.17	17.65	17.91
LSD $_{(p \leq 0.05)}$ (V)	0.9		-	0.84		-
LSD $_{(p \leq 0.05)}$ (C)	0.65		-	0.59		-
LSD $_{(p \leq 0.05)}$ (V×C)	1.3		-	1.19		-

*PC = Protective condition; *OF = Open field condition; V = Variety; C = Condition

Table 4. Effect of protective covering and open field condition on acidity in grapes.

Variety	**Acidity (%)**					
	2018			**2019**		
	PC	**OF**	**Mean**	**PC**	**OF**	**Mean**
Perlette	0.69^{a}	0.70^{a}	0.69	0.68^{a}	0.69^{a}	0.68
Flame Seedless	0.65^{ab}	0.67^{a}	0.66	0.66^{a}	0.67^{ab}	0.66
Superior Seedless	0.60^{d}	0.65^{a}	0.62	0.62^{a}	0.66^{ab}	0.64
Punjab Purple	0.65^{a}	0.70^{a}	0.67	0.60^{a}	0.60^{c}	0.6
Mean	0.64	0.68	0.66	0.64	0.66	0.65
LSD $_{(p \leq 0.05)}$ (V)	1.12		-	NS		-
LSD $_{(p \leq 0.05)}$ (C)	0.79		-	NS		-
LSD $_{(p \leq 0.05)}$ (V×C)	1.59		-	NS		-

*PC = Protective condition; *OF = Open field condition; V = Variety; C = Condition

Total sugars

The observations regarding the effect of protective covering on total sugars are given in Table 6. The data revealed that maximum total sugars (15.4% in 2018 and 14.8% in 2019) were recorded in Punjab Purple grapes under protective covering which was statistically at par with Flame Seedless grapes with TS 14.7% grown under protective covering in 2018 and with Perlette (13.8%) in 2019. Minimum TS was observed in Superior Seedless Grape in both seasons which was 11.8% in 2018 and 11.3% in 2019 under open field conditions. Likewise,

Coban (2007) stated that in covered, plastic covering increased substantially the amounts of fructose and α-glucose in Cardinal, Yalova Incisi, and Round Seedless grape varieties.

Table 5. Effect of protective covering and open field condition on TSS: acid ratio in grapes.

Variety	TSS/Acid ratio					
	2018			2019		
	PC	OF	Mean	PC	OF	Mean
Perlette	26.0 [a]	24.4 [a]	25.2	26.4[bc]	25.2[cd]	25.8
Flame Seedless	28.5 [a]	26.8 [a]	27.6	28.8[b]	27.7[bc]	28.3
Superior Seedless	27.5[a]	24.3 [a]	25.9	26.1[bcd]	23.6[d]	24.8
Punjab Purple	31.2 [a]	27.1 [a]	29.2	32.5[a]	31.7[a]	32.1
Mean	28.3	25.6	26.9	28.4	27	27.7
LSD $_{(p \leq 0.05)}$ (V)	9.73		-	1.9		-
LSD $_{(p \leq 0.05)}$ (C)	6.88		-	1.3		-
LSD $_{(p \leq 0.05)}$ (V×C)	13.77		-	2.69		-

*PC = Protective condition; *OF = Open field condition; V = Variety; C = Condition

Table 6. Effect of protective covering and open field condition on total sugar ratio in grapes.

Variety	Total Sugar (%)					
	2018			2019		
	PC*	OF*	Mean	PC	OF	Mean
Perlette	13.6[c]	12.7[d]	13.2	13.8[ab]	13.0[bc]	13.4
Flame Seedless	14.7[ab]	14[bc]	14.3	13.3[bc]	13.0[bc]	13.2
Superior Seedless	12.7[d]	11.8[e]	12.3	12.3[cd]	11.3[d]	11.8
Punjab Purple	15.4[a]	14.6[b]	15	14.8[a]	13.0[bc]	13.9
Mean	14.1	13.3	13.7	13.5	12.6	13
LSD $_{(p < 0.05)}$ (V)	0.56		-	0.85		-
LSD $_{(p \leq 0.05)}$ (C)	0.39		-	0.6		-
LSD $_{(p \leq 0.05)}$ (V×C)	0.79		-	1.21		-

*PC = Protective condition; *OF = Open field condition; V = Variety; C = Condition

Anthocyanin (mg/100 g pulp)

The data regarding the effect of protective covering on total anthocyanin contents are presented in Table 7. The data revealed that the maximum total anthocyanin contents were found in Punjab Purple grapes in both seasons which was 68.0 mg under a protective covering in 2018 (higher than open field condition), and in 2019, it was 68.8 mg under a protective covering. In Flame Seedless, total anthocyanin contents were found under protective covering which were 27.9 mg in 2018 and 28.75 mg in 2019 whereas in open field condition, it was 26 mg in 2018 and 26.3 mg in 2019 (lower than protected condition). Souza *et al* (2015) reported that berries under diffused plastic showed the highest anthocyanins concentration, and also the use of diffused plastic induced more agronomical benefits to producing Syrah grape under protected cultivation. Li *et al* (2014) stated that the concentrations of most anthocyanins were significantly enhanced in the rain-shelter cultivated grapes.

Table 7. Effect of protective covering and open field condition on Total Anthocyanins in grapes.

Variety	Total Anthocyanins (mg/100 gm pulp)					
	2018			2019		
	PC*	OF*	Mean	PC	OF	Mean
Flame Seedless	27.90[c]	26.00[d]	26.95	28.75[c]	26.30[d]	27.52
Punjab Purple	68.00[a]	66.30[b]	67.15	68.80[a]	66.65[b]	67.72
Mean	47.95	46.15	47	48.77	46.47	47.62
LSD $_{(p \leq 0.05)}$ (V)	0.36		-	0.49		-
LSD $_{(p \leq 0.05)}$ (C)	0.25		-	0.34		-
LSD $_{(p \leq 0.05)}$ (V×C)	0.50		-	0.69		-

*PC = Protective condition; *OF = Open field condition; V = Variety; C = Condition

CONCLUSION

Grape is one of the most important crops grown almost all over the world for its economic value. Farmers can obtain higher incomes by producing high-quality grapes. Production of grapes under protective covering results in higher-quality fruit crops. The result of our studies suggested that protective covering is a new technology that improved fruit quality attributes viz fruit size, TSS, acidity, TSS: acid ratio, total sugar, and total anthocyanins contents of grapes. Moreover, this technology protects the crops from natural calamities, and biotic and abiotic stress.

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