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OPTIMIZATION OF BUNCH LOAD IN RELATION TO JUICE QUALITY IN MANJARI MEDIKA GRAPE

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ABSTRACT

Bunch thinning is important practice for enhancing the grape quality and yield. The effects of bunch load on yield and berry quality in 'Manjari Medika' juice purpose grape variety was evaluated during 2019-20. Four bunch load levels (40, 60, 80 and 100 bunches/vine) were maintained at fruit setting stage. Bunch size and berry weight were decreased with the increase in bunch load. However, Manjari Medika being a processing variety, irrespective of its reduction in berry size, juice recovery per unit area along with its juice quality in terms of antioxidant properties is important. Higher bunch load /vine delayed the maturity by a week, from the juice, compounds viz., gallic acid, quercetin hydrate, caftaric acid, resveratrol, chlorogenic acid, kaempferol, catechin hydrate, and epicatechin were analyzed. Significant variations were observed in the concentrations of these compounds across the bunch levels while, indicating a potential relationship between bunch size and phenolic compound accumulation. Higher antioxidant content was recorded at 60 and 80 bunch loads at harvest. Considering the juice recovery with maintained quality, yield and antioxidant content, 80 bunches/ vine can be more beneficial to processing industry.

Key words : Manjari Medika, Juice recovery, Quality, Bunch load, Antioxidant property.

Introduction

Grapes (*Vitis vinifera* L.) it is most important export-oriented fruit crop in country, contributing significantly to the international market due to presence of their exquisite flavors and premium quality. It is grown on an area of about 1.62 lakh hectare with annual production of 3489.40tons (Anonymous, 2023). In addition, it is one of the most nutritious, globally cherished, refreshing, commercial, favorite and delicious fruit crops worldwide (Kedage *et al.*, 2007). Although, India is predominant in grape cultivation, approximately 78 percent of total productionis used for table purpose, almost 17–20 percent is dried for raisin production, while and the remaining 2% is utilized in the production of juice and wine (Somkuwar *et al.*, 2020). The health concern of consumers is provoking the development of processing industries of grapes to harness the health benefits. It is beneficial for reducing diabetes mellitus, cardiovascular disorders and digestive problems due to their antioxidant, antimicrobial and anti-inflammatory properties (Imran *et al.*, 2017). The higher antioxidant properties of available in fresh grapes as well as dried fruit (raisin) fight against the health diseases. Antioxidants are mainly concentrated in berry skin and seeds of the grape berry. More numbers of antioxidants are being contributed by the colored varieties because of the anthocyanin content which provides colour to the berry (Paun *et al.*, 2022). Khan *et al.* (2021) reported positive correlation of phenol content with antioxidant activity. However, vineyard yield and quality of grape are strongly influenced by viticultural practices like canopy management (Somkuwar *et al.*, 2014a). Among the several techniques, bunch load management is the most important cultural practice followed as it not only maintains and increase productivity but also has pronounced effect on the distribution of photo assimilates and the source-sink relationship between leaves and fruits of vineyard which adjust balanced between development and yield (Somkuwar *et al.*, 2014). Heavy crop load can delay harvesting period and reduce fruit and wine quality (Sharma *et al.*, 2017 and Somkuwar *et al.*, 2020). However, it can be beneficial with some of juice purpose varieties like 'Manjari Medika' while, bunch load management is crucial viticulture practice in arid and semi-arid climates, and it is applied to increase the quality of the harvest.

Considering the health consciousness, one of the varieties developed at ICAR-National Research Centre for Grapes, Pune named as 'Manjari Medika' suitable for juice purpose and production of processed product is gaining popularity due to its higher antioxidant properties. It is a colored (skin and pulp) seeded variety with good amount of juice content. Because of its very high yielding capacity, the present study was conducted to identify the optimum bunch load to recover the maximum yield without much reduction in its antioxidant compounds.

Materials and Methods

The experiment was performed at the farm of ICAR-National Research Centre for Grapes Pune during 2019-2020. Pune (18.32°N and 73.51°E) has warm and dry climate with temperature ranging from 20 to 28°C. Ten-year-old vines of Manjari Medika grafted onto Dogridge rootstock were selected for the study. The vines were planted in N-S direction with spacing of 3.0 × 1.83 m between the rows and vines with the vine density of 1815 vines per hectare. These vines were trained onto Y-trellises with four cordons in horizontal orientation and vertical shoot positions.

The fruit pruning was done in first week of October during the years. Shoot thinning was done to maintain the canopy size before inflorescence emergence. Bunch thinning was completed after berry setting (at pea size) under each treatment. The bunch load was maintained by retaining 40, 60, 80 and 100 clusters/vine, respectively. The experiment was laid out in randomized block design (RBD) with five replications. Five vines were selected under each replication to record the observations. To study the effect of bunch load treatments on yield, quality, fruit compositions and biochemical constituents, bunches under each treatment were harvested on the same date. All bunch and berry observations were recorded at uniform level of total soluble solids (20-21 °Brix).

Yield and quality parameters

At harvest, average bunch weight, 50-berry weight, yield/vine, berry length, berry diameter, acidity, juice content, days to veraison, days to achieve uniform color and days to harvest were recorded.

Average bunch weight (g)

The mean weight of five randomly selected healthy bunches per replication was recorded after harvesting, and their combined weight was measured using a weighing balance. The resulting average bunch weight was then expressed in grams.

50 berry weight (g)

Fifty berries were selected from five different bunches in each replication, and the weight 50 berries was measured using a weighing balance. The average weight of 50 berries was calculated and expressed in grams.

Yield (kg/vine)

After the maturity, the grapes from five vines in each treatment were harvested and weighed using a balance. The average yield per vine was calculated and expressed in kilograms.

Berry diameter (mm)

Berry diameter was measured by collecting 10 berries from each of the five bunches on individual vines using a vernier caliper and expressed in millimeters.

Berry length (mm)

Ten berries were collected from five bunches on individual vines and berry length was measured using vernier calipers and expressed in millimeters.

Acidity (g/l)

The total acidity (TA) determination was done by using Oeno Foss (FTIR based wine analyzer) and expressed in g/L. Randomly hundred berrieswere selected from each replicate and processed in a blender and strained through two layers of muslin cloth and extracted juice from crushed berries was centrifuged at 5000 rpm for 5 min used for analysis.

Juice content (%)

The juice content of grape berries was calculated by using following formula:

$$Juice\ \ percentage = \frac{Total\ weight\ of\ \ juice(g)}{Total\ weight\ of\ \ fruit(g)} \times 100$$

Days to veraison

Days taken for veraison was calculated from the date of fruit pruning to veraison for individual vine and mean was recorded.

Days to uniform colour development

Days taken to achieve uniform colour was calculated from the date of fruit pruning to uniform berry colour development for individual vine and mean was recorded.

Biochemical determinations

The antioxidant compounds were analyzed using an Agilent Technologies HPLC system from the 1260 series. The system included a built-in 4-channel degassing unit, a standard auto-sampler, a 1260 infinity quaternary pump, an Agilent 1260 infinity Diode array detector and an injector. To control, acquire data, and conduct further analysis, the system was connected to a personal computer running the Agilent EZ chrome elite software. For the chromatographic separation, a Zorbax Eclipse plus C18 column (4.6 mm × 100 mm, 1.8 µm particle size) was used, preceded by a C18 guard column to prevent contamination by non-soluble residues from the samples. The injection volume was set at 10µl and the flow rate was maintained at 0.80 mL/minute. The mobile phase, composed of A (0.2% acetic acid in 10% acetonitrile) and B (0.2% acetic acid in acetonitrile), had a gradient of 95% A and 5% B. Before use, the solvent underwent filtration through a vacuum filter and was then sonicated for 5-10 minutes in an ultrasonic bath to eliminate air bubbles. The column temperature was held constant at 30°C, and peaks were detected at 280 nm for all antioxidant compounds.

Statistical analysis

The data were recorded as an average for all the different parameter studied. The experiment was laid out in randomized block design consisting of four treatments as different bunch load. All calculations were completed using the GLM procedure of SAS System software, version 9.3.

Results and Discussion

Effect of bunch load on bunch and berry quality

The data recorded on yield and quality parameter of different bunch load are presented in Table 1. Bunch weight and berry weight was significantly increased with the decrease in crop load. The mean bunch weight for T_1 was significantly higher (294.5 g) compared to T_4 (219.2 g). Similarly, T_1 had the highest average berry weight (150.4 g), while, T_4 had the lowest (110.0 g). A positive corelation was also observed with bunch weight and berry weight (Table 2). The higher crop loads had negative impact on bunch and berry size. The present result confirms the studies carried out in grapes by Popovic *et al*. (2023); Coban, (2023); Somkuwar *et al*. (2020). Increase in bunches per vine and bunch weight was resulted into increased yield per vine. Significantly higher yield was obtained with increase in crop load. The treatment T_4 had the highest yield (21.9 kg), while T_1, had the lowest yield (11.6 kg). This finding reveals that a higher crop load contributes to higher yields in Manjari Medika. A strong negative corelation was found with yield and berry diameter and length in relation to bunch load. Berry diameter and length showed significantly inverse relationship with crop load. The bunch load treatment T_1 showed the largest berries with the highest diameter (17.3 mm) and length (19.3 mm), while T_4 had the smallest berries with the lowest diameter (14.6 mm) and length (17.0 mm). These results highlight the impact of crop load on berry size. Earlier reports revealed that highest bud load decreases berry length and diameter in Cardinal grapes (Popovic *et al*., 2023), Somkuwar *et al*. (2020) on Thompson Seedless and Somkuwar *et al*. (2014) on Jumbo Seedless grapes. Acidity increased significantly with higher crop loads, as shown by T_4 having the highest acidity (5.61 g/l). These findings suggest that higher crop loads negatively influence fruit quality in terms of acidity. However, the juice content increased with increasing crop load, with T_3 and T_4 having the highest juice content (68.98 and 68.32%), respectively. Days to veraison, uniform colour, and harvest all exhibited a positive correlation with crop load (Table 2). As crop load increased, the days to these developmental stages also increased. T_1 showed the earliest days to veraison (74.8 DAP), uniform colour (90.5 DAP) and harvest (118.30 DAP), while in $T_{4,}$ the period was delayed. This result suggests that higher crop loads postponed the ripening and harvesting in Manjari Medika. The results of heavy cluster thinning on yield components were studied by many workers (Somkuwar and Ramteke, 2010; Bubola *et al.*, 2011; Gil *et al.*, 2013; Somkuwar *et al*., 2014; Somkuwar *et al*., 2020; Popovic *et al*., 2023 and Coban *et al*., 2023). In all studies, it is mentioned that the rate of decrease in crop yield with bunch thinning was compensated through increase in bunch and berry weight and improvement in quality. This response was reported due to higher photo-assimilates accumulation in clusters on the vines with lower bunch load. Popovic *et al*. (2023) reported that the increased in yield was found in 18 buds per vine of Cardinal variety while, highest sugar content and quality was obtained 8 bud per vine.

Effect of bunch load on antioxidants content

The profiling of Manjari Medika for antioxidant properties revealed the presence of antioxidant property governing compounds (gallic acid, quercetin hydrate, resveratrol, chlorogenic acid, kaempferol, catechin hydrate, epicatechin) at veraison and harvest stage (Table 3, Figs. 1 and 2). In general, all these compounds showed rise at harvesting stage, except catechin hydrate and epicatechin. Significant variation was recorded for the

Table 1 : Analysis of variance for various bunch and berry traits at four crop load level in Manjari Medika.

Treatment	Bunch weight (g)	50 Berry weight (g)	Yield/ vine (kg)	Berry diameter (mm)	Berry length (mm)	Acidity (g/l)	Juice content (%)	Days to veraison (DAP)*	Days to uniform color	Days to harvest (DAP)*
T_1	294.5a	150.4a	11.6d	17.3a	19.3a	4.83d	65.01c	74.8c	90.5c	118.30b
T_2	264.7b	135.6b	15.9c	16.9b	18.2b	5.13c	66.83b	75.7bc	92.2b	120.51b
T_3	247.2c	122.9c	19.8b	16.0c	18.0c	5.46b	68.98a	77.5ab	94.4a	125.54a
T_4	219.2d	110.0d	21.9a	14.6d	17.0d	5.61a	68.32a	79.3a	95.4a	128.38a
Mean	256.43	129.72	17.45	16.21	18.14	5.26	67.29	76.83	93.12	123.19
LSD (5%)	5.59	1.30	0.18	0.02	0.05	0.099	1.13	1.98	1.22	4.05
Pr > F	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

*Days after fruit pruning.

Table 2 : Correlation matrix for nine morphological parameters in relation to bunch load.

Parameters	Load	Bunch weight	Berry weight	Yield	Berry diameter	Berry length	Acidity	Days to veraison	Days to achieve uniform colouration	Days to harvest
Load	1.00	-0.98	-0.99	0.99	-0.96	-0.93	0.99	0.98	0.99	0.97
Bunch weight		1.00	0.99	-0.99	0.92	0.97	-0.98	-0.94	-0.97	-0.93
Berry weight			1.00	-0.99	0.95	0.94	-0.99	-0.97	-0.99	-0.96
Yield				1.00	-0.96	-0.94	0.99	0.97	0.99	0.97
Berry diameter					1.00	0.80	-0.97	-0.99	-0.98	-0.99
Berry length						1.00	-0.92	-0.84	-0.90	-0.83
Acidity							1.00	0.98	0.99	0.98
Days to veraison								1.00	0.99	0.99
Days to achieve uniform colouration									1.00	0.98
Days to harvest										1.00

antioxidant compounds at different crop load level at veraison stage, but these differences were lowered down at harvesting. Antioxidants are known for medicinal properties.At veraison, the mean concentration of gallic acid decreased with increasing bunch numbers (0.42, 0.43, 0.37, 0.37 mg/kg for 40, 60, 80 and 100 bunches, respectively). A similar trend was observed at harvest, with the highest concentration in 100 bunches (0.37 mg/kg) and the lowest in 80 bunches (0.34 mg/kg). The decline in gallic acid concentration during the harvest period is due to the increase in phenolic compounds during veraison, thereby enhancing the antioxidant capacity studies conducted by Yilmaz *et al*. (2004) and Tierney *et al*. (2006). Quercetin hydrate concentrations at veraison, was increased from 40 to 60 bunches but decreased at 80 and 100 bunches. At harvest, the highest concentration was observed in 100 bunches (55.83 mg/kg), while the lowest was in 40 bunches (51.74 mg/kg). Experiencing elevated temperatures during the ripening process modifies the distribution of anthocyanins, resulting in an increased presence of quercetin 3-glucoside in grape composition (Tarara *et al.*, 2008). The Caftaric acid concentrations decreased at veraison with increasing bunch numbers while at harvest, the highest concentration was observed in 40 bunches (1.93 mg/kg) and the lowest in 100 bunches (1.57 mg/kg). Caftaric acid fluctuations had seen according to bunch load in grapes due to berry enlargement during ripening stage with the proportion of coutaric to caftaric and percentage of cis forms increasing toward the end of ripening (Singleton *et al*., 1986). Resveratrol concentration was consistent across all bunches per vine at veraison. However, at harvest, significant differences were observed, with the highest concentration in 40,60 and 80 bunches (0.066, 0.078 & 0.078 mg/kg, respectively) and the lowest in 100 bunches (0.040 mg/kg). Calzarano *et al*. (2008) reported that the

Table 3 : Antioxidant content at veraison and harvest stage of Manjari Medika at different crop loads (mg/kg of fruits).

Treatments		40 bunches (T_1)	60 bunches (T_2)	80 bunches (T_3)	100 bunches (T_4)	Mean	LSD (5%)	Pr > F
Gallic acid	Veraison	0.428a	0.432a	0.370b	0.378b	0.40	0.012	<.0001
	Harvest	0.35b	0.36ab	0.34b	0.37a	0.35	0.024	0.016
Quercetin hydrate	Veraison	0.37b	0.61a	0.17b	0.26b	0.355	0.215	0.0004
	Harvest	51.74c	54.92ab	53.93b	55.83a	42.10	1.58	<.0001
Caftaric acid	Veraison	1.32b	1.35a	1.01d	1.04c	1.18	0.011	<.0001
	Harvest	1.938a	1.634b	1.632bc	1.576c	1.695	0.058	<.0001
Resveratrol	Veraison	0.012a	0.012a	0.012a	0.012a	0.012	0.000	<.0001
	Harvest	0.066a	0.078a	0.078a	0.040b	0.065	0.024	0.002
Chlorogenic acid	Veraison	0.59b	0.61a	0.55c	0.53d	0.57	0.008	<.0001
	Harvest	11.51b	14.75a	14.41a	12.75b	13.35	1.555	0.0001
Kaempferol	Veraison	0.032a	0.020b	0.018b	0.010c	0.02	0.006	<.0001
	Harvest	0.036a	0.019a	0.013a	0.019a	0.021	0.050	0.538
Catechin hydrate	Veraison	1.35b	7.61a	0.93d	0.96c	2.71	0.009	<.0001
	Harvest	0.00b	0.00b	27.57a	0.00b	…	0.004	<.0001
Epicatechin	Veraison	2.34b	2.86a	1.84c	1.75d	2.20	0.015	<.0001
	Harvest	0.00b	0.00b	0.012a	0.00b	…	0.004	<.0001

Table 4 : Estimation of correlation of eight antioxidant components in relation to bunch load during harvest.

Paramters	Bunch load	Gallic acid	Quercetin hydrate	Cafteric acid	Resvera-trol	Chloro-genic acid	Kaemp-ferol	Catechin hydrate	Epicate-chin
Bunch load	1.00	0.72	0.83	-0.85	-0.56	0.29	-0.65	0.26	0.26
Gallic acid		1.00	0.81	-0.61	-0.83	-0.05	-0.33	-0.48	-0.48
Quercetin hydrate			1.00	-0.94	-0.39	0.54	-0.82	-0.07	-0.07
Cafteric acid				1.00	0.18	-0.71	0.94	-0.25	-0.26
Resveratrol					1.00	0.55	-0.16	0.46	0.46
Chlorogenic acid						1.00	-0.91	0.47	0.47
Kaempferol							1.00	-0.39	-0.39
Catechin hydrate								1.00	1.00
Epicatechin									1.00

average trans-resveratrol concentration in berries exhibits a rise, going from 0.93 and 1.92µg/g_{dm} during veraison to 1.14 and 2.72µg/g_{dm} at harvest, observed in both healthy and symptomatic vines. This trend aligns with the findings of Wang *et al*. (2015 and 2016). The concentration of Kaempferol decreased with increasing bunch numbers at both veraison and harvest. The highest concentration of catechin hydrate was observed in 60 bunches at veraison (7.61 mg/kg) and in 80 bunches at harvest (27.57 mg/kg). Catechin hydrate increases in grapes as a linear function of concentration, affecting astringency and bitterness (Robichaud and Noble, 1990). Grape seed extract contains various natural procyanidin dimers and trimers, which may be responsible for the variation in epicatechin content among different grape varieties (Silva *et al*., 1991). Kennedy *et al*. (2000) observed a reduction in the levels of several polyphenols and alterations in their composition during veraison due to oxidation occurring during fruit ripening. However, quercetin and resveratrol protect against high risk for cancer and heart disease.

The correlation of the compounds (Table 4) showed the reverse trend such as cafteric acid (-0.85), resveratrol (-0.56) and kaempferol (-0.65) with increase in crop load during harvest. However, gallic acid (0.72) and quercetin hydrate (0.83) had positive correlation with the bunch

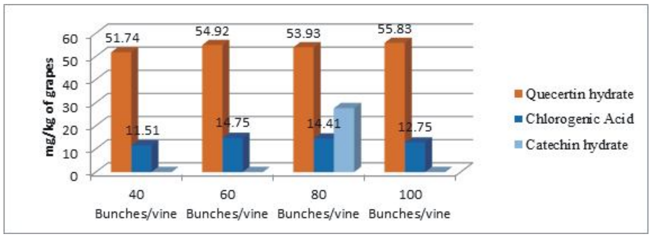

Fig. 1 : Influence of bunch load of Manjari Medika on quercetin hydrate, chlorogenic acid and catechin hydrate quantity.

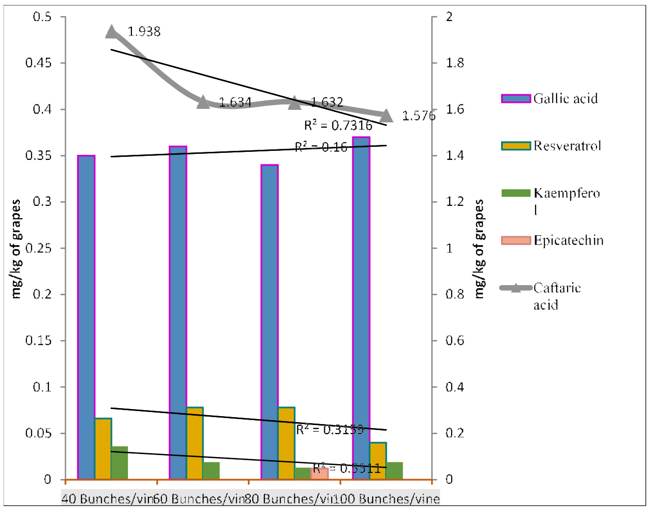

Fig. 2 : Effect of bunch load of Manjari Medika on gallic acid, resveratrol, kaempferol, epicatechin and caftaric acid quantity.

load. Higher resveratrol content was recorded at 60 and 80 bunch load level during harvest, but reduction was observed further with increase in bunch load (100 bunches/ vine). Intermediate level of quercetin hydrate (53.93 mg), caftaric acid (1.93 mg) and chlorogenic acid (14.41 mg) was quantified at 80 bunch loads as compared to its lower and higher load level. Yield with higher cluster thinning had advanced ripening and better phenolic content compared to higher bunch load. Carmona *et al*. (2021) reported that harvesting grapes at an intermediate ripeness stage, specifically when the degree brix falls within the 15-16 range, is ideal for obtaining a high concentration of phenolic compounds and antioxidant activity from the grapes. Similar trend was observed in the present study where the development of uniform color in berries was achieved 5 days in advance. Also, the harvesting was achieved 10 days early attaining 20-21°B total soluble solids at 40 bunches/vine crop load (Garrido *et al*., 2016). Comparatively higher total phenols, flavan-3-ols and anthocyanin concentration was obtained at higher level of bunch and berry thinning and vice-versa (Bubola *et al*., 2011 and Karoglan *et al*., 2014). While, Liu *et al.* (2016) reported significant increase in total phenols, flavanols, flavanoids, anthocyanin content in skin and wine with increase in grape compactness. Even, better quantity of flavonoids in the grapes matures under winter condition, which received longer sunshine hour and lower temperature (Cheng *et al*., 2019).

Manjari Medika is high yielding variety, but retaining all bunches on vine will degrade its nutritional value. Therefore, the question of retention of number of bunches without much degradation in its health benefits was addressed in this study. The combination of berry and bunch parameters and concentrations of antioxidant compounds at various bunch loads indicates the yield with 80 bunches vine^{-1} in Manjari Medika is comparatively beneficial in terms of economics and its nutritional value.

Conclusion

Manjari Medika is a processing variety for juice purpose. Therefore, combinations of higher yield with quality in terms of sugar, acidity and enriched antioxidant property have commercial value. Although, the harvesting period was delayed to get the required quality produce such as development of uniform color and to attain 20-21°B total soluble solids, higher crop load will be more economical. Higher yield with increase of 8.2 kg was recorded at 80 bunch loads with maximum juice recovery (68.98%) and harvesting time was delayed by 8 days. In addition to higher produce, quality in terms of antioxidant contents was also maintained intermediately at 80 bunch/ vine load. The present findings highlight the importance of bunch load management in Manjari Medika for processing purposes, as it provides economic advantages and maintain the balance between yield, juice recovery and nutritional value of the grapes such as antioxidant and phenolic compound, which has potential health benefits, that helps combat against chronic diseases.

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