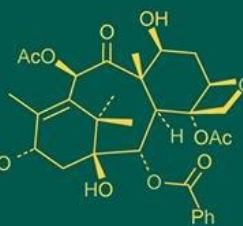


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Standardization of bunch load in relation to juice quality in Manjari Medika grapevine grafted on Dogridge rootstock

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Abstract

This study investigates the standardization of bunch load in Manjari Medika grapevines grafted onto Dogridge rootstocks to enhance juice quality and yield. Grapes (*Vitis vinifera* L.) are a significant export-oriented fruit crop known for their nutritional and antioxidant properties, which contribute to health benefits such as reducing diabetes and cardiovascular disorders. The focus variety, Manjari Medika, is valued for its high antioxidant content and juice yield. While, its high productivity requires standardization of bunch load to balance fruit quality and yield. The two-year study was conducted at ICAR National Research Centre for Grapes, Pune, using five different bunch load treatments (50, 60, 70, 80 and all bunches per vine) laid out in a randomized block design. Parameters measured included phenological stages, yield, berry size, total soluble solids (TSS), acidity, juice recovery and biochemical constituents such as phenols, anthocyanins, proline, carbohydrates and proteins. Sensory evaluations of the juice were also conducted. Results revealed that reducing bunch load to 60-70 bunches per vine accelerated ripening and colour development, enhanced berry weight, increased TSS and sugar-acid ratio and improved phenolic and anthocyanin content. These improvements translated into superior sensory attributes including colour, flavor, consistency, taste and overall acceptability. Conversely, retaining all bunches increased yield and juice recovery but diluted quality parameters and extended maturity. The study highlights a critical trade-off between quantity and quality, demonstrating that moderate thinning optimizes source-sink balance, facilitating better assimilate distribution and enhancing grape berry quality. In conclusion, managing bunch load at 60-70 bunches per vine optimizes juice quality and antioxidant content in Manjari Medika grapes, thereby improving their nutritional value and market potential while sustaining satisfactory yields.

Keywords: Juice recovery, Manjari Medika, antioxidant activity, bunch load

Introduction

Grapes (*Vitis vinifera* L.) represent one of the most significant export-oriented fruit crops in the country, playing a crucial role in the international market owing to their exceptional flavor and premium quality. Cultivated across approximately 1.76 lakh hectares, annual grape production stands at 3896.40 tons (Anonymous, 2024) [2]. Grapes are globally recognized as a highly nutritious, refreshing and commercially favoured fruit crop (Kedage *et al.*, 2007) [3]. In India, grape cultivation is predominant, with about 78% of the total production for table consumption, 17-20% processed into raisins and the remaining 2% utilized for juice and wine production (Somkuwar *et al.*, 2020) [4, 20]. Growing consumer health awareness has encouraged the development of grape processing industries to harness the fruit's health-promoting properties. Grapes exhibit beneficial effects in mitigating diabetes mellitus, cardiovascular disorders and digestive issues, attributed to their antioxidant, antimicrobial and anti-inflammatory properties (Imran *et al.*, 2017) [7]. Both fresh grapes and dried forms (raisins) possess high antioxidant activity, with the majority of these compounds concentrated in the berry skin and seeds. Coloured grape varieties contribute more antioxidants due to their anthocyanin content, which imparts colour to the berries (Paun *et al.*, 2022) [9]. A positive correlation has been reported between phenolic content and antioxidant activity (Khan *et al.*, 2021) [8]. Vineyard yield and grape quality are significantly influenced by viticultural practices, particularly canopy management (Somkuwar *et al.*, 2014a) [5, 22].

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Among these, bunch load management is a critical cultural practice, as it not only maintains and enhances productivity but also regulates the distribution of photo assimilates and the source-sink relationship between leaves and fruits, thereby balancing development and yield (Somkuwar *et al.*, 2014) [5, 22]. Excessive crop load can delay harvest and diminish fruit and wine quality (Sharma *et al.*, 2018; Somkuwar *et al.*, 2020) [10, 4, 20].

Materials and Methods

The experiment was performed at the farm of ICAR National Research Centre for Grapes Pune during 2023-2025. Pune (18.32°N and 73.51°E) has warm and dry climate with temperature ranging from 20 to 28 °C. Seven-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 80, 70, 60, 50 and All bunches per vine (80-120 bunches/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, data on yield and quality parameters such as average bunch weight, berry diameter, yield per vine, acidity, total soluble solids (TSS), juice recovery and phenological stages (days to veraison, colour development and harvest) were recorded. Average bunch weight was determined from five randomly selected healthy bunches per replication using a digital weighing balance and expressed in grams. Berry diameter was measured in millimeters using a Vernier caliper from ten berries collected across five bunches per vine. Yield per vine (kg) was calculated from the total bunch weight of five representative vines in each treatment. Acidity (%) was estimated by titrating 10 mL of juice, extracted from fifty berries, against 0.1 N NaOH using phenolphthalein as an indicator. Juice recovery (%) was determined by manually crushing destemmed berries in a sieve with a pestle (Dumas *et al.*, 2020) [11], weighing the extracted juice and expressing it as a percentage of fresh

berry weight. The number of days to veraison, colour development and harvest (20 °Brix) were recorded from the date of fruit pruning and the mean values were calculated for each vine.

Biochemical parameters

The biochemical parameters were analysed in berries. The total carbohydrate content was estimated by Anthrone method (Hedge and Hofreiter, 1962) [13], reducing sugar by DNSA method (Miller, 1959) [14], the total phenolic content using Folin-Ciocalteu method (Singleton and Rossi, 1965) [15], the protein content (Lowry *et al.*, 1951) [16], the proline content (Bates *et al.*, 1973) [17], the colour intensity (Glories, 1984) [18] and total anthocyanins (Lee, 2005) [19].

Statistical Analysis

The experiment was conducted using a Randomized Block Design (RBD) with five bunch loads as treatments which were replicated five times. Data collected during the experiment was analyzed using the standard method of analysis of variance described by Panse and Sukhatme (1985) [12].

Results and Discussion

Manjari Medika grapevine grafted on Dogridge rootstocks had significant effect on phenological stages (Table 1). During both the year and in pooled analysis, significantly minimum number of days taken for veraison, colour development and harvesting were recorded in vines with 50 bunches (76.26, 95.95 and 125.16 days, respectively) which was found significantly superior over all other treatments. It was followed by 60 bunches (79.83, 98.02 and 126.50 days, respectively) while, the maximum number of days taken for veraison, colour development and harvesting were observed in the all-bunches treatment (86.21, 103.68 and 139.30 days, respectively). The present study demonstrated that the minimum number of bunches per vine significantly reduced the days taken to veraison, colour development and harvesting while, retaining all bunches delayed veraison, colour development and harvesting in Manjari Medika grafted on Dogridge. Somkuwar *et al.*, (2020) [4, 20] reported that Manjari Naveen with higher bunch load took extra one week to attain veraison and harvesting. This aligns with reports that cluster or bunch thinning advances maturity and increased TSS and enhanced colour development by improving assimilate availability and canopy microclimate (Pastore *et al.*, 2011; Petrie and Clingeleffer, 2006) [32, 31]. Similar trends have been reported across cultivars and climates were reducing cluster load advanced ripening (higher TSS) which enabling earlier harvest in Chenin Blanc and Syrah (Somkuwar *et al.*, 2018) [21] and in Tempranillo heavy loads slightly delayed harvest dates by ~3 days when LA: Y fell below 1 m² kg⁻¹ (Uriarte *et al.*, 2016) [30].

Table 1: Effect of different bunch load on days taken for veraison, days taken for colour development and days taken for harvesting of Manjari Medika grapevines grafted on Dogridge rootstock

Parameter/Bunches	Days taken for veraison			Days taken for colour development			Days taken for harvesting		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
80 bunches	83.93	85.53	84.73	102.27	101.86	102.07	133.89	131.06	132.48
70 bunches	81.87	84.21	83.04	101.11	100.14	100.62	131.13	127.48	129.31
60 bunches	78.05	81.61	79.83	97.98	98.05	98.02	128.89	124.11	126.50
50 bunches	75.97	76.54	76.26	95.63	96.27	95.95	127.33	122.99	125.16
All bunches	85.75	86.67	86.21	103.91	103.45	103.68	139.96	138.64	139.30
S.Em. (±)	0.74	0.54	0.47	0.30	0.36	0.28	0.44	0.52	0.35
CD at 5 %	2.23	1.61	1.42	0.91	1.09	0.83	1.33	1.55	1.05

The average bunch weight, berry diameter and yield was significantly influenced by the bunch load during both years of study and in pooled data (Table 2). In pooled data, the maximum bunch weight and berry diameter per vine were recorded in vines retained with 50 bunches (331.95 g and 17.59 mm) which was significantly superior to all other treatments. It was followed by 60 bunches (308.41 g and 16.91 mm respectively) while, the minimum bunch weight and berry diameter was recorded in vines with all bunches retained (235.76 g and 15.06 mm respectively). Contrary to this, the highest yield was recorded in vines where all bunches were retained (23.58 kg/vine) which was significantly superior to all other treatments. It was followed by 80 bunches (20.67 kg/vine) and 70 bunches (19.27 kg/vine) while, the lowest yield was observed in 50 bunches (16.61 kg/vine). These results reinforced the findings of Jia

Nan *et al.*, (2023) who reported that light, moderate and heavy berry thinning increased berry weight and yield in Baoguang and Cuiguang. This significant difference indicated that moderate bunch load optimizes berry size, likely due to reduced competition for assimilates among developing berries a trend that aligns with prior grapevine studies (Somkuwar *et al.*, 2014b) ^[5, 22]. Somkuwar *et al.*, (2020) ^[4, 20] documented that Manjari Naveen with 40 bunches per vine had maximum berry diameter and yield in 100 bunches per vine. Similar trends have been reported in Syrah, Chenin Blanc and Cardinal, where thinning increased berry size and cluster weight despite overall yield reduction, reinforcing a generalizable crop-load-berry-size relationship across table and wine grapes (Somkuwar *et al.*, 2018; Popović *et al.*, 2023) ^[21, 3].

Table 2: Effect of different bunch load on average bunch weight (g), berry diameter (mm) and yield (kg/vine) of Manjari Medika grapevines grafted on Dogridge rootstock

Parameter/Bunches	Average bunch weight (g)			Berry diameter (mm)			Yield (kg/vine)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
80 bunches	269.17	247.55	258.36	15.40	16.36	15.88	21.53	19.80	20.67
70 bunches	287.27	263.39	275.33	16.09	17.05	16.57	20.11	18.44	19.27
60 bunches	322.52	294.31	308.41	16.43	17.39	16.91	19.35	17.66	18.50
50 bunches	344.63	319.25	331.94	17.05	18.13	17.59	17.25	15.96	16.61
All bunches	248.87	222.66	235.76	14.52	15.59	15.06	24.89	22.27	23.58
S.Em. (±)	2.21	3.02	2.57	0.21	0.20	0.20	0.26	0.21	0.23
CD at 5 %	6.62	9.08	7.70	0.64	0.60	0.61	0.79	0.62	0.68

The berry quality parameters were significantly influenced by different bunch load treatments in the year 2023-24, 2024-25 and pooled data (Table 3). In pooled data, the maximum TSS and Sugar acid ratio were recorded in 50 bunches (22.04°Brix and 38.29, respectively) which was at par with 60 bunches (21.47°Brix and 35.72, respectively) while, the minimum TSS was again found in the all bunches (19.15°Brix and 27.82, respectively). Contrary to this, in pooled data, significantly minimum acidity was recorded in vines with 50 bunches (0.58%) which was at par with 60 (0.60%) while, the highest acidity was recorded in all bunches (0.69%). Total soluble solids (TSS) in grapes are strongly governed by source-sink balance, canopy microclimate, crop load and water status, with consistent evidence that moderated bunch load enhances sugar accumulation while excessive load depresses it. This pattern suggests that lower bunch load favours sugar accumulation in berries, consistent with findings in grapevine crop load studies (Somkuwar *et al.*, 2020; Somkuwar *et al.*, 2020a) ^[4, 20]. Acidity in grape berries affected by crop load, vine

vigor, canopy microclimate and water status. The reduced bunch load lowers titratable acidity (TA) and heavier crop loads maintain higher TA through slower ripening and greater malate retention (Somkuwar and Ramteke, 2006c; Somkuwar *et al.*, 2020) ^[25, 28, 4, 20]. Similar patterns are reported in Chenin Blanc and Syrah under tropical conditions where lower clusters increased TSS and reduced TA, with higher cluster loads elevating TA and must pH (Somkuwar *et al.*, 2018) ^[21]. The sugar: acid ratio is a pivotal integrator of grape maturity and juice balance, rising as sugars accumulate and titratable acidity declines and it is strongly modulated by crop load and canopy-source dynamics across cultivars and climates (Somkuwar *et al.*, 2018; Al-Saif *et al.*, 2023) ^[21, 26]. Similar crop-load benefits on TSS and acidity were reported in Chenin Blanc and Syrah, where reduced cluster number increased soluble solids, decreased TA and improved must composition, aligning with classic source-sink theory (Somkuwar *et al.*, 2018) ^[21].

Table 3: Effect of different bunch load on TSS (Total soluble solids), acidity (%) and sugar: acid ratio of Manjari Medika grapevines grafted on Dogridge rootstock

Parameter/Bunches	TSS (°Brix)			Acidity (%)			Sugar: acid ratio		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
80 bunches	19.53	20.40	19.96	0.70	0.64	0.67	27.77	31.83	29.69
70 bunches	19.58	20.65	20.12	0.68	0.60	0.64	28.71	34.35	31.35
60 bunches	20.88	22.05	21.47	0.64	0.56	0.60	32.55	39.35	35.72
50 bunches	21.60	22.47	22.04	0.61	0.54	0.58	35.29	41.70	38.29
All bunches	18.86	19.43	19.15	0.72	0.66	0.69	26.23	29.59	27.82
S.Em. (±)	0.23	0.21	0.21	0.01	0.01	0.01	0.29	0.67	0.36
CD at 5 %	0.70	0.65	0.63	0.03	0.03	0.03	0.87	2.01	1.07

The juice pH was not significantly influenced by bunch load during both year and pooled data, as differences were statistically non-significant. However, juice recovery was significantly influenced by bunch load treatments (Table 4). In pooled data, the maximum juice recovery was recorded in all bunch treatment (70.20%) which was followed by 70 bunches (68.88%) while, the least recovery was noted in 50 bunches per vine (60.35%). Juice recovery in grapes is strongly modulated by bunch load, berry size, skin to pulp ratio and associated compositional changes, with consistent evidence that higher bunch loads increase percent juice yield at the expense of solute concentration and berry mass,

whereas lower loads reduced juice recovery but enhance quality attributes such as TSS, phenolics and colour intensity (Somkuwar *et al.*, 2006c; Somkuwar *et al.*, 2018; Somkuwar *et al.*, 2020a)^[25, 28, 21, 4, 20]. This trade-off aligns with increased cluster numbers elevate yield and juice volume per vine but dilute sugars and reduce average berry and bunch weight whereas thinning boosts TSS, sugar: acid ratio, phenolics, anthocyanins and colour, all of which correlate with lower juice percent due to thicker skins and denser cellular matrices (Uriarte *et al.*, 2016; Wang *et al.*, 2018)^[30, 33].

Table 4: Effect of different bunch load on juice pH and juice recovery (%) of Manjari Medika grapevines grafted on Dogridge rootstock

Parameter/Bunches	Juice pH			Juice recovery (%)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
80 bunches	3.73	3.65	3.69	67.30	69.27	68.28
70 bunches	3.68	3.60	3.64	67.47	70.29	68.88
60 bunches	3.69	3.61	3.65	65.84	67.81	66.82
50 bunches	3.65	3.57	3.61	58.95	61.75	60.35
All bunches	3.75	3.67	3.71	68.50	71.91	70.20
S.Em. (±)	0.03	0.03	0.03	0.62	0.77	0.63
CD at 5 %	NS	NS	NS	1.88	2.32	1.91

The total phenol, carbohydrates and protein content were significantly influenced by bunch load during both years and in pooled data (Table 5). The vines with 50 bunches recorded the highest phenol, carbohydrates and protein content (2.20, 281.85 and 14.85 mg/g, respectively) which was significantly superior to all other treatments. It was followed by 60 bunches (1.93, 275.74 and 13.66 mg/g respectively) whereas, the lowest phenol, carbohydrate and protein content were observed in vines with all bunches per vine (1.26, 254.12 and 9.03 mg/g). Total phenol, carbohydrates and protein content in grape berries

consistently increases as bunch load is reduced which is reflecting a favourable shift in the source-sink balance that enhances secondary metabolism and phenylpropanoid flux toward phenolics under lower competition for assimilates (Somkuwar and Ramteke, 2006d; Somkuwar *et al.*, 2014a)^[25, 28, 5, 22]. Complementary studies by Somkuwar *et al.*, (2020)^[4, 20] in Thompson Seedless for raisins also observed increasing total phenols, with higher bunch load. Similar patterns have been reported in Chenin Blanc and Syrah where lower cluster load increased soluble solids and berry carbohydrates (Somkuwar *et al.*, 2018)^[21].

Table 5: Effect of different bunch load on total phenol (mg/g), carbohydrates (mg/g) and protein (mg/g) of Manjari Medika grapevines grafted on Dogridge rootstock

Parameter/Bunches	Total phenol (mg/g)			Carbohydrates (mg/g)			Protein (mg/g)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
80 bunches	1.42	1.52	1.47	268.93	261.05	264.99	10.14	11.11	10.63
70 bunches	1.75	1.84	1.79	278.70	267.20	272.95	11.49	12.69	12.09
60 bunches	1.89	1.97	1.93	280.99	270.49	275.74	12.97	14.35	13.66
50 bunches	2.31	2.09	2.20	287.01	276.69	281.85	14.16	15.55	14.85
All bunches	1.22	1.31	1.26	258.00	250.25	254.12	8.43	9.63	9.03
S.Em. (±)	0.01	0.02	0.01	0.53	1.16	0.70	0.17	0.11	0.09
CD at 5 %	0.04	0.06	0.03	1.60	3.48	2.11	0.51	0.32	0.26

The proline content in grape berries was significantly influenced by different bunch load levels during both years and in the pooled data (Table 6). In pooled analysis, the lowest proline accumulation was recorded in vines with 50 bunches per vine (2.50 µmol/l) which was significantly superior to all other treatments. It was followed by 60 bunches (2.56 µmol/g) while, the highest value was observed in all bunches (3.21 µmol/g). Whereas, the maximum colour intensity anthocyanins were recorded in 50 bunches per vine (2.23% and 237.15 mg/100g respectively) which was significantly superior to all other treatments. It was followed by 60 bunches (2.08% and 232.20 mg/100g respectively) while, the lowest intensity was observed in the all-bunches treatment (1.46% and 235.26 mg/g

respectively). Proline serves as an osmoprotectant and ROS scavenger thus, vines under higher metabolic or environmental stress often show greater proline in fruit tissues during late development (Jackson and Lombard, 1993)^[29]. Lower crop load typically improves leaf area per fruit and light-air penetration, hastening ripening and phenolic development while moderating stress signaling which can depress proline biosynthesis or accumulation in berries (Somkuwar *et al.*, 2018; Somkuwar *et al.*, 2020)^[21, 4, 20]. Colour intensity in grape berries is profoundly shaped by crop load mediated shifts in source: sink balance, canopy microclimate and phenolic biosynthesis, with consistent evidence that moderate thinning elevates colour metrics via enhanced anthocyanin and co-pigment accumulation while

excessive loads depress them through delayed ripening and dilution effects (Somkuwar and Ramteke, 2006c; Somkuwar *et al.*, 2020) [25, 28, 4, 20]. Somkuwar *et al.*, (2018) [21] and Wang *et al.*, (2018) [33] reported that cluster thinning improves light interception and lowers canopy competition, accelerating veraison and colour development, while raising berry skin phenolics including total phenols and flavonoids

that contribute to optical density and co-pigmentation. Anthocyanin accumulation in grape berries is strongly modulated by crop load, microclimate and hormonal cues, with bunch thinning at lower loads consistently elevating total anthocyanins and color intensity by improving source: sink balance and light exposure (Somkuwar *et al.*, 2014) [5, 22].

Table 6: Effect of different bunch load on proline ($\mu\text{mol/g}$), colour intensity (%) and anthocyanin (mg/g) of Manjari Medika grapevines grafted on Dogridge rootstock

Parameter/Bunches	Proline ($\mu\text{mol/g}$)			Colour intensity (%)			Anthocyanin (mg/100g)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
80 bunches	2.91	2.97	2.94	1.43	1.66	1.55	290.36	278.36	284.36
70 bunches	2.64	2.68	2.66	1.87	2.10	1.99	328.94	317.00	322.97
60 bunches	2.54	2.58	2.56	1.96	2.19	2.08	337.20	327.20	332.20
50 bunches	2.48	2.51	2.50	2.11	2.34	2.23	343.15	331.15	337.15
All bunches	3.27	3.15	3.21	1.35	1.58	1.46	241.26	229.26	235.26
S.Em. ($\pm$)	0.02	0.03	0.02	0.02	0.02	0.01	2.70	2.36	2.23
CD at 5 %	0.07	0.09	0.05	0.05	0.06	0.05	8.09	7.09	6.69

Reducing sugars content in grape berries was also significantly influenced by the different bunch load (Table 7). The highest reducing sugar content was recorded in 50 bunches per vine (237.80 mg/g) which was significantly superior to all other treatments. It was followed by 60 (231.60 mg/g) while, the lowest reducing sugar was recorded in the all-bunches treatment (210.87 mg/g). Reducing sugars in grape berries primarily glucose and fructose are central to ripening, sensory quality and they respond strongly to bunch load. Consistently, lowering

bunch load increases sugar accumulation per berry by improving the source: sink balance, enhancing leaf area effectiveness and advancing ripening, whereas heavy loads dilute assimilates, delay maturity and depress reducing sugars at harvest or drying endpoints (Somkuwar *et al.* 2006; Somkuwar *et al.* 2020) [4, 20]. In Thompson Seedless, reducing sugar in raisins declined from 7.80 to 5.10 mg g^{-1} as bunch load increased from 50 to 125 clusters per vine (Somkuwar *et al.* 2020a) [4, 20].

Table 7: Effect of different bunch load on reducing sugar (mg/g) of Manjari Medika grapevines grafted on Dogridge rootstock

Parameter/Bunches	Reducing Sugar (mg/g)		
	2023-24	2024-25	Pooled
80 bunches	221.67	206.67	214.17
70 bunches	229.45	214.45	221.95
60 bunches	239.10	224.10	231.60
50 bunches	245.30	230.30	237.80
All bunches	218.37	203.37	210.87
S.Em. ($\pm$)	1.82	1.49	1.32
CD at 5 %	5.46	4.49	3.97

4.2.4 Effect of different bunch load on organoleptic properties of Manjari Medika grapevine juice

The sensory evaluation of Manjari Medika grape juice from grapevines grafted on Dogridge rootstock showed that varying bunch load significantly impacted the overall sensory attributes, including colour, flavor, consistency, taste and overall acceptability during both the year and pooled data are graphically presented in Fig. 1. Among the different bunch load treatments, the juice from vines retained with 50 bunches per vine consistently received the highest scores across all sensory parameters in both 2023-24 and 2024-25 seasons as well as pooled data.

Specifically, 50 bunches treatment recorded superior colour (7.8), flavor (8.8), consistency (8.5), taste (8.5) and overall acceptability (8.8). This suggests that moderate thinning of bunches enhances desirable sensory qualities likely due to improved ripening, higher sugar accumulation and better phenolic concentration enhancing flavor and mouthfeel. The

60 bunches treatment followed closely with good sensory acceptability highlighted that moderately reduced crop load balances yield and quality well. In contrast, the all-bunches treatment represented highest crop load which showed the lowest sensory ratings with colour (6.6), flavor (8.0), consistency (7.3), taste (7.2) and overall acceptability (7.6). The moderate bunch load thinning (around 50-60 bunches per vine) significantly improved grape juice quality by enhancing sensory traits. This improvement is due to better ripening, sugar accumulation and phenolic content achieved by reducing competition among berries within the vine (Jackson and Lombard, 1993; Somkuwar *et al.*, 2020) [29, 4, 20]. Excessive bunch load delays maturity, dilutes flavor compounds and reduces sensory quality (Reynolds *et al.*, 2007). Thus, managing bunch load balances yield and sensory excellence by optimizing physiological and biochemical fruit attributes (Somkuwar and Ramteke, 2006) [25, 28].

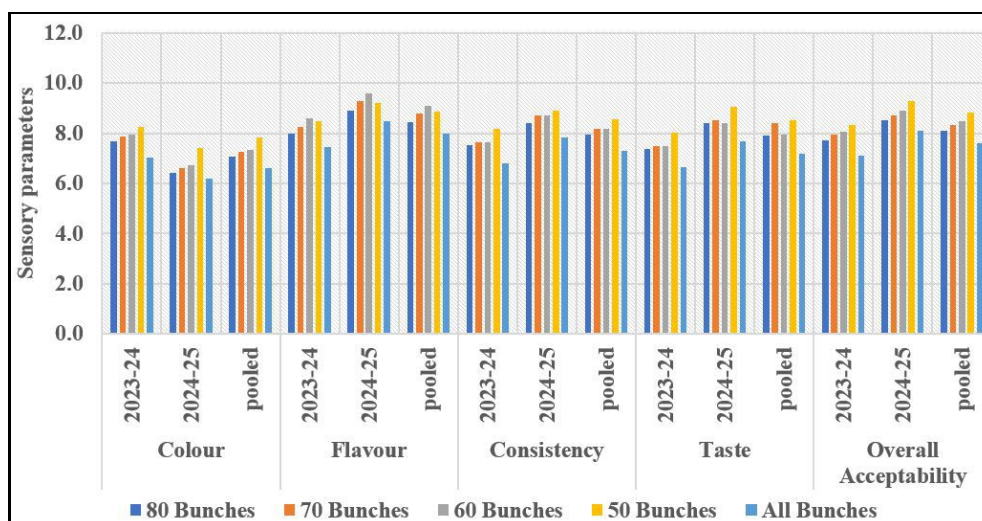


Fig 1: Effect of different bunch load on sensory evaluation of Manjari Medika grapevines grafted on Dogridge rootstock

Conclusion

The study on Manjari Medika grapevines grafted to Dogridge rootstocks demonstrates that standardization of bunch load is critical for balancing yield and juice quality. Retention of 60-70 bunches per vine consistently resulted in superior berry weight, higher sugar and phenolic concentrations, improved organoleptic characteristics of the juice and accelerated berry maturity compared to all bunch treatment. While increasing bunch load boosts overall yield and juice recovery, but lower the berry quality parameters and overall acceptability. These findings emphasize that careful bunch load management produce quality grape juice and improve nutritional and market value of grape juice in Manjari Medika Grapevine.

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