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Leaf Area Influences Photosynthetic Activity, Yield, Quality and Juice Recovery in Manjari Medika Grape

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ABSTRACT

The study was conducted at ICAR-National Research Centre for Grapes, Pune during October 2023 to March 2024 to assess the leaf area requirement of Manjari Medika grape variety. The variation in leaf above the bunch on a fruit bearing shoot was created such as 10, 12, 14, 16 and >16 leaves. Manjari Medika grapevines grafted on Dogridge rootstock, spaced at 9×5 ft trained to extended Y- trellis was selected for the study. Maximum bunch weight (375.30 g), 50-berry weight (106.49 g), TSS (20.40˚B), yield vine^{-1} (29.20 kg) and juice recovery (70.25%) as well as highest photosynthetic activity such as assimilation rate (14.50 μmol CO_2 m^{-2} s^{-1}) and transpiration rate (2.64 mmol H_2O m^{-2} s^{-1}) and total chlorophyll content (45.25 mg ml^{-1}) was observed in 12 leaves shoot^{-1} above the bunch while, minimum bunch weight (320.10 g), 50-berry weight (92.55 g), TSS (18.60˚B), yield vine^{-1} (25.60 kg) and juice recovery (65.30%) were observed in 16 leaves above the bunch. However, the leaf area shoot^{-1} (2760.80 cm^2), leaf area vine^{-1} (69020.00 cm^2) and leaf area bunch^{-1} (878.12 cm^2) were found sufficient for quality grape and juice production, which was achieved by maintaining 12 leaves (878.12 cm^2) per shoot above the bunch which ensured high-quality grape and juice production in Manjari Medika grape.

KEYWORDS: Grape, leaf area, Manjari Medika, photosynthetic activity, yield

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1. INTRODUCTION

Grape (*Vitis vinifera* L.) is important fruit crop cultivated on an area of about 1.62 lakh ha under tropical condition in India (Somkuwar et al., 2023) with approximately 34.45 lakh mt of produce (Thutte et al., 2024). The primary grape growing regions in the country are Maharashtra, Karnataka, Tamil Nadu, and Mizoram (Somkuwar et al., 2024). Manjari Medika, a teinturier grape variety developed by ICAR-NRC for Grapes has higher juice recovery with higher antioxidant properties. It is gaining popularity because of high yielding, its medicinal property and quality juice production in Maharashtra (Somkuwar et al., 2024b). However, for getting optimum and good quality produce canopy management practices plays an important role. Canopy management treatments, such as pruning, trimming and leaf removal, can be used to maintain vine source-sink balance (Candar et al., 2020). In the tropical parts of the country where the grapes are being grown for table, wine and juice purpose, it is important to manage the canopy in terms of leaf area, shoot density/ vine for the production of quality grapes and also to minimize the disease incidence. It is also said to increase the photosynthetic efficiency of the vine (Somkuwar et al., 2012). Leaf area vine^{-1} (source) regulates carbohydrate production and determine how much crop (sink) can be produced. However, distribution of that photosynthate into overall vine determine the harvest index (Petrie et al., 2000). While, leaf area index (LAI), defined as the total one-sided area of leaf tissue per unit ground surface area, is an important agronomical parameter related to photosynthetic capacity, water use, microclimate, canopy vigor, grape quality and enological potential (Orlando et al., 2016). The optimum leaf area and canopy development allows evaluating plant health conditions and guide management practices, including crop protection and canopy adjustments (Junges et al., 2019). The ability of the vine to early harvesting is mostly determined by their total leaf area and percentage of total leaf surface exposed to sunlight (Suklje et al., 2013). However, the process of removing leaves from the fruiting area, is a commonly adopted technique in vineyards with vigorously growing vines trained vertically. This practice, usually executed between the stages of fruit-set and veraison. Furthermore, the enhanced direct exposure of fruits to sunlight elevates their temperature, facilitating the degradation of malic acid, refining the sugar-acid ratio, and particularly enhancing the aroma potential, notably in grape varieties (Poni et al., 2008). Interestingly, studies have shown that removing leaves from the lower quarter of the canopy during the lag-phase of berry growth leads to a significant decrease in whole-vine photosynthesis, even on a per-unit leaf area basis. This suggests that the lower portion of the canopy contributes more to the vine's overall carbon budget than the upper portion (Candar et al., 2020; Suklje et al., 2013; Poni et al., 2008). Young leaves generally start to produce excess photo assimilates, translocated afterwards to the other parts of the vine after they reach one third of their full sizes, approximately 5 or 6 weeks after leaf unfolding (Candar et al., 2020). Depending on leaf age, regardless of whether they come from the lateral or main shoot, individual photosynthetic activities are effective in berry ripening and in sugar accumulation in grape juice (Candar et al., 2020). Due to this phenomenon, it is important to point out the role of leaf removal practices about ripening processes. Several workers reported that minimum leaf area for adequate grape ripening per gram of fruit is between 7 to 14 cm^2 g^{-1}, varying between cultivars and trellis system (Suklje et al., 2013; Petrie et al., 2000). Considering the above, the present study was designed to assess the leaf area requirement of Manjari Medika grape variety.

2. MATERIALS AND METHODS

The study was conducted at the farm of ICAR-National Research Centre for Grapes, Pune during October, 2023 to March, 2024. The experimental site is situated in Mid-West Maharashtra at an altitude of 559 m above mean sea level (18.32°N and 73.51°E). Manjari Medika grape variety was grafted onto Dogridge rootstocks in August 2017 at a spacing of 9×5 ft thus accommodating 968 vines acre^{-1}. The vines were trained to extended Y-trellis and followed standard recommended cultural practices during the period of study. Different leaf area was created by altering the number of leaves above the bunch. Five different treatments were evaluated, each corresponding to 10, 12, 14, 16 and >16 number of leaves per shoot abovethe bunch was replicated five times. The observations recorded were as below.

2.1. Photosynthetic parameters

LAI and PAR was recorded with the help of LaiPen LP 110. (LAI=Leaf area/ground area, m^2 m^{-2}) in broadleaf canopies. The photosynthetically active radiation (PAR) was quantified as μmol photons m^{-2} s^{-1}, which is a measure of the photosynthetic photon flux density (PPFD). Photosynthetic rate, stomatal conductance and transpiration rate were recorded using Infra-Red Gas Analyzer made in USA (IRGA model Li 6400, LI-COR Biosciences, NE, USA). Matured leaves i.e., fifth to sixth from tip were used for measuring these parameters. Observations were recorded during bright sunlight at 11 am to 12.30 pm.

2.2. Leaf area

Leaf area was measured by linear method (LBK method) and expressed in cm^2. The mathematical relationship for calculation was given as follows; Leaf area (A)=L×B ×K (0.810). Total leaf area per shoot was calculated by multiplying leaf area per leaf to total number of leaves per shoot. Total leaf area per vine was calculated by multiplying leaf area per shoot to total number of shoot vine^{-1}. Total leaf area per bunch was calculated by dividing leaf area vine^{-1} to total number of bunches vine^{-1} and was expressed in cm^2.

2.3. 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.

2.4. 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 and expressed in grams.

2.5. No. of berries bunch^{-1}

Number of berries per bunch calculated from five bunches in each treatment and the average was calculated.

2.6. Yield (kg vine^{-1})

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

2.7. Total soluble solids (TSS)

TSS is the total sugar content. The value displayed is based on the ratio of the speed of light in a vacuum and the speed of light through the sample. Refractometer was used to measure the TSS of grape berries. The berries were squeezed and the grape juice samples was placed on portable handheld refractometer (Erma Refractometer, Japan) at room temperature. TSS value were expressed in °Brix. All the experimental measurements were replicated 3 times.

2.8. Acidity (g l^{-1})

The total acidity (TA) determination was done by using OenoFoss (FTIR based wine analyzer) and expressed in g l^{-1}. Randomly hundred berries were 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.

2.9. Juice recovery (%)

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

Juice percentage=(Total weight of juice (g)/Total weight of fruit (g))×100

2.10. Estimation of chlorophyll

Chlorophyll was estimated by Arnons (1949) method. The leaves from different treatments were cut into small pieces and 1 g of sample was homogenized in chilled 80% acetone in mortar and pestle. The acetone extract was filtered through Whatman No. 1 filter paper. The final volume of the extract was made to 100 ml with 80% acetone. The absorbance of acetone extract was read at 645 and 663 nm using UV-visible spectrophotometer (Shimadzu-1601) using 80% acetone as a reference.

$$\text{Chl a}=11.75\times A663-2.35\times A645$$

$$\text{Chl b}=18.61\times A645-3.96\times A663$$

$$\text{Total chl}=\text{chl a}+\text{chl b}.$$

2.11. Statistical analysis

The field experiment was conducted in Randomized Block Design (RBD) consisting of five treatments as number of leaves above the bunch which was replicated five times. Statistical analysis of data collected during the course of studies was carried out by standard method of analysis of variance as described by Panse and Sukhatme (1995). The Pearson correlation coefficient was used to determine the correlation between different growth and yield parameters. The standard error of mean (SEm±) was worked out and the critical difference at 5% and 1% level of significance was calculated wherever the results were found significant.

3. RESULTS AND DISCUSSION

The data recorded on leaf area leaf^{-1} shoot^{-1} vine^{-1}, per bunch and leaf area per gram of berry weight is presented in Table 1. It was observed that as the number of leaves per shoot increased, there was decrease in leaf area per leaf from 170.60 to 125.30 cm^2. The leaf area per shoot and per vine also showed similar trends. As the number of leaves per shoot increased, there was decrease in leaf area shoot^{-1} and vine^{-1} (2559.00 to 3132.50 cm^2 and 61416.00 to 78312.50 cm^2 respectively). The leaf area bunch^{-1} ranged from 767.77 to 978.90 cm^2 also exhibited a declining trend with an increase in the number of leaves shoot^{-1}. The leaf area g^{-1} of berry weight provided insight into the efficiency of resource utilization in grapevine productivity. Interestingly, there was gradual increase in leaf area per gram of berry weight with an increase in the number of leaves shoot^{-1} (2.07 to 3.05 cm^2 g^{-1}). This result suggested as more leaves are present, there is a greater allocation of resources towards berry development relative to leaf area. This could imply a potential trade-off between vegetative growth and reproductive output in grapevines. As more leaves are developed on a shoot, resources such as light and nutrients becomes proportionally distributed, leading to a reduction in individual leaf size. More number of leaves contribute to overall vine foliage, there was a diminishing return in terms of total leaf area with each additional leaf. More open canopy leading to synthesis of more photosynthetic assimilates as

Table 1: Effect of leaves on total leaf area in Manjari Medika variety

Leaves above the bunch	Leaf area leaf^{-1}	Leaf area shoot^{-1} (cm^2)	Leaf area vine^{-1} (cm^2)	Leaf area bunch^{-1} (cm^2)	Leaf area g^{-1} berry wt. (cm^2 g^{-1})
T_1: 10 leaves above the bunch	170.60	2559.00	61416.00	767.77	2.07
T_2: 12 leaves above the bunch	162.40	2760.80	69020.00	878.12	2.33
T_3: 14 leaves above the bunch	155.30	2950.80	73770.00	927.92	2.61
T_4: 16 leaves above the bunch	142.45	2991.45	74786.25	917.62	2.67
T_5: 16 leaf above the bunch	125.30	3132.50	78312.50	978.90	3.05
SEm±	1.06	22.99	551.83	7.41	0.02
CD (p=0.05)	3.19	68.93	1654.39	22.23	0.06

effect of more exposed leaf surface area to sunlight reported by Somkuwar et al. (2019). Candar et al. (2020) found similar results in Merlot grapes during their three years study at Turkey, showed desirable difference in leaf area vine^{-1} ranging from 1.92 to 6.54 m^2 vine^{-1}. Somkuwar et al. (2019) suggested that higher leaf count may contribute to increased photosynthetic activity, it does not necessarily translate to a proportional increase in grapevine yield. The reduction in leaf area bunch^{-1} might be attributed to resource allocation dynamics within the vine, where resources are distributed among a larger number of leaves rather than being concentrated on a fewer number of bunches. However, similar results were also reported by Somkuwar et al. (2024c, 2024d and 2024e) suggested that maintaining 12 leaves above the bunch with 63820.80 cm² leaf area per vine in Crimson Seedless, 14 leaf above the bunch with 69312.00 cm² leaf area per vine in Manjari Kishmish and 10 leaf above the bunch with 59400.00 cm² leaf area per vine in Nanasaheb Purple seedless were sufficient for higher yield and better-quality grapes.

The data recorded on effects of different leaves per shoot on grapevine productivity (yield) and grape characteristics (quality) are presented in Table 2. The average bunch weight ranged from 320.10 g to 375.30 g among the different treatments. Treatment with 12 leaves above the bunch showed the highest average bunch weight (375.30 g), while treatment with >16 leaves above bunch exhibited the lowest average bunch weight (320.10 g). However, it was noticed that the average bunch weight increased slightly as the number of leaves per shoot increased beyond 10 leaves and decreased above 14 leave shoot^{-1}. The difference obtained in bunch weight might be due to the availability of leaves shoot^{-1} and several other factors such as climatic conditions, vine age, and cultural practices. Number of bunches vines^{-1} ranged from 78.60 to 81.50 with the highest number observed in >16 leaves above bunch (81.50 bunches vine^{-1}) while the lowest in the treatment with 12 leaves above bunch (78.60 bunches vine^{-1}). However, these differences were not statistically significant. Similarly, the number of berries per bunch did not show significant variation among the treatments. Fifty berry weight and yield vine^{-1} varied significantly among the different leaf retention treatments ranging from 92.55 g to 106.49 g and 25.60 kg to 29.20 kg respectively. Highest 50-berry weight and yield were recorded in 12 leaves above bunch (106.49 g and 29.20 kg respectively) followed by 10 leaves above bunch (105.65 g and 28.80 respectively) while, lowest yield/vine and 50-berry weight were recorded in >16 leaves above bunch (25.60 kg and 92.55 g respectively). Juice recovery ranged from 65.30% to 70.25% across the treatments studied where

Table 2: Effect of leaves on bunch characters, berry quality and yield in Manjari Medika

Leaves above the bunch	Average bunch weight (g)	No of bunches vine^{-1}	No of berries bunch^{-1}	50-berry weight (g)	Yield vine^{-1} (kg)	Juice recovery (%)	TSS (°Brix)	Acidity (g l^{-1})
T_1: 10 leaves above the bunch	370.20	80.0	175.32	105.65	28.80	68.30	21.00	5.20
T_2: 12 leaves above the bunch	375.30	86.00	176.20	106.49	29.20	70.25	20.40	5.35
T_3: 14 leaves above the bunch	355.20	79.50	173.50	102.36	28.06	67.30	19.65	5.25
T_4: 16 leaves above the bunch	342.60	81.50	175.40	98.50	27.70	66.50	19.40	5.30
T_5: 16 leaf above the bunch	320.10	80.00	174.80	92.55	25.60	65.30	18.60	5.10
SEm±	2.43	NS	NS	0.70	0.19	0.47	0.13	0.03
CD (p=0.05)	7.29	NS	NS	2.10	0.57	1.40	0.39	0.10

the treatment with 12 leaves shoot^{-1} resulted in highest juice recovery and treatment with >16 leaves above bunch resulted in the lowest juice recovery. The manipulation of leaf-to-shoot ratios might have indirectly influenced juice recovery through its effects on grapevine physiology, canopy microclimate, and nutrient availability. The observed trend of higher juice recovery in treatments with a moderate leaf-to-shoot ratio (treatment with 12 leaves above bunch) could be attributed to optimized vine balance. The increase in number of leaves increases the canopy volume thereby reducing the chances of absorption of sunlight required for photosynthesis. This condition might have resulted into reduced storage of food material required for the berry development. Moderate canopy density and leaf area might have facilitated better light penetration and air circulation within the canopy, promoting optimal fruit development and ripening. Additionally, balanced vegetative growth and fruit load distribution could have contributed to enhanced grape quality and juice extraction efficiency. The result of the present study aligns with the findings of Candar et al. (2020) who reported lowest yield (4.60 kg vine^{-1}) for non-lateral shoot (NLS) and highest (5.00 kg vine^{-1}) for half lateral shoot FLS (3–4 leaves) application. Impact of leaf-to-shoot ratio on total soluble solids (TSS) and acidity is presented in Table 3. Decrease in TSS levels was observed as the number of leaves shoot^{-1} increased. The treatment with 10 leaves above bunch exhibited the highest TSS in grape berries (21.00°Brix), while the treatment with >16 leaves above bunch showed the lowest TSS (18.60°Brix). This negative correlation between leaf-to-shoot ratio and TSS suggested that a higher leaf density shoot^{-1} might hinder the accumulation of soluble solids in the plant tissues. Auzmendi et al. (2014) observed that the optimum leaf area to fruit weight ratios varied during ripening within certain ranges, (8 to 10 cm^2 g^{-1}) for total soluble solids concentration (TSSC). Conversely, the acidity levels, was measured in grams per litre. The acidity ranged from 5.10 g l^{-1} in the treatment with >16 leaves above bunch to 5.35 g l^{-1} in the treatment with 12 leaves above bunch. Korkutal et al. (2017) reported that the complete removal of the lateral leaves increases the total acidity. Horak et al. (2021) also reported reduction of leaf area can favor nutrient intake, the removal of 70% of leaf area led to the accumulation of lesser quantities of sugar in the grapes; therefore, these grapes contained the lowest values of TSS. Similarly to the TSS, TA increased with the leaf area. Cataldo et al. (2021) highlighted that reducing leaf number during berry growth can lead to changes in the growth curve of berries, affecting sugar accumulation and acid levels. This result also in line with Somkuwar et al. (2024c, 2024d and 2024e) who reported that maintaining 12 leaves above the bunch in Crimson Seedless,14 leaves above the bunch in Manjari Kishmish and 10 leaves above the bunch in Nanasaheb Purple Seedless lead to enhance the productivity and raisin quality.

Table 3: Effect of leaves on LAI and PAR of vine in Manjari Medika variety

Leaves above the bunch	LAI (m^2 m^{-2})	PAR (μ mol photon m^{-2} S^{-1})
T_1: 10 leaves above the bunch	2.10	0.95
T_2: 12 leaves above the bunch	2.48	0.74
T_3: 14 leaves above the bunch	2.80	0.65
T_4: 16 leaves above the bunch	3.15	0.55
T_5: 16 leaf above the bunch	3.60	0.30
SEm±	0.02	0.005
CD (p=0.05)	0.08	0.017

The leaf area index (LAI) was critical parameter indicating the leaf area per unit ground area, which directly influences photosynthetic activity and overall plant productivity. The treatments with varying leaf numbers per shoot demonstrated significant effects on LAI (Table 4). As the number of leaves above bunch increased, there was an increase in LAI. Specifically, the LAI increased progressively from 2.10 in 10 leaves above bunch to 3.60 in >16 leaves above bunch. This result suggests that an increase in leaf

Table 4: Effect of leaves on photosynthetic activities in Manjari Medika variety

Leaves above the bunch	Assimilation rate (μmol CO_2 m^{-2} s^{-1})	Stomatal conductance (mmol CO_2 m^{-2} s^{-1})	Intercellular CO_2 (Ci) (ppm)	Transpiration rate (mmol H_2O m^{-2} s^{-1})
T_1: 10 leaves above the bunch	14.30	0.13	242.50	2.63
T_2: 12 leaves above the bunch	14.50	0.13	243.20	2.64
T_3: 14 leaves above the bunch	13.50	0.15	243.50	2.62
T_4: 16 leaves above the bunch	12.48	0.14	240.35	2.55
T_5: 16 leaf above the bunch	12.00	0.11	243.65	2.53
SEm±	0.09	0.001	NS	0.01
CD (p=0.05)	0.28	0.003	NS	0.05

density positively correlates with a higher leaf area per unit ground area. Photosynthetically active radiation (PAR) represents the portion of the electromagnetic spectrum crucial for photosynthesis. Similar to LAI, the treatments exerted discernible effects on PAR values. Contrary to LAI, as the number of leaves per shoot increased, the PAR values exhibited a declining trend. The PAR values decreased progressively from 0.95 μmol photon m^{-2} s^{-1} (10 leaves above the bunch) to 0.30 μmol photon $m^{-2}s^{-1}$ (>16 leaves above the bunch), Similar results were also reported by Burg et al. (2017) in nine different grape varieties. Kang et al. (2022) reported that LAI ranged from 0.8 to 2.4, 1.0 to 4.0 and 0.7 to 4.0 m^2 m^{-2} in Cabernet Sauvignon, Chardonnay and Pinot Noir grapes respectively. Thoke et al. (2024) conducted research on nine varieties and found largest leaf area index (3.91 m^2 m^{-2}) in Thompson Seedless while the lowest in Nanasaheb Purple Seedless (3.68 m^2 m^{-2}) and Crimson Seedless (3.87 m^2 m^{-2}) after foundation pruning. Also, similar result also found by Somkuwar et al. (2024c, 2024d and 2024e) that the leaf area index (LAI) of Crimson Seedless, Manjari Kishmish and Nanasaheb Purple Seedless increased with the number of leaves above the bunch (1.33 to 2.02, 1.42 to 1.66 and 1.42 to 2.16 m^2/m^2 respectively) while, PAR value reduced as number of leaves increased from 0.59 to 0.41, 0.14 to 0.94 and 0.15 to 0.09 μmol photon m^{-2} s^{-1} respectively.

The effects of varying leaf density $shoot^{-1}$ on photosynthetic parameters including assimilation rate, stomatal conductance, intercellular CO_2 concentration and transpiration rate are summarized in Table 5. Assimilation rate was key indicator of photosynthetic efficiency, exhibited a slight variation across different leaf densities per shoot. The mean assimilation rates ranged from 12.00 to 14.50 μmol CO_2 μmol CO_2 m^{-2} s^{-1}. Although, assimilation rate decreased with increasing leaf density $shoot^{-1}$ was observed, with the highest assimilation rate recorded in 12 leaves above bunch, while, lowest in >16 leaves above bunch. From the result it was concluded that an optimal leaf density may exist for maximizing photosynthetic efficiency. Stomatal conductance, which regulates the exchange of CO_2 and water vapor between the leaf and the atmosphere, showed minimal variation among the treatments. The values ranged from 0.11 to 0.15 mmol CO_2 mmol CO_2 m^{-2} s^{-1}. Intercellular CO_2 concentration, indicative of the internal CO_2 concentration within the leaf, remained relatively stable across treatments ranging from 240.35 to 243.65 ppm. Transpiration rate reflecting the water loss through leaf stomata showed minor fluctuations across treatments. The values ranged from 2.53 to 2.64 mmol H_2O m^{-2} s^{-1}, with the highest transpiration rate in 12 leaves above bunch treatment. Results of the present investigation are also in line with Somkuwar et al. (2014) who reported that canopy manipulation practices had no marked stimulating effect on stomatal conductance. Maximum rate of transpiration (3.05 μmol m^{-2} s^{-1}) was recorded with shoot pinching at 10 leaves above the bunch in Tas-A-Ganesh grapes. Somkuwar et al. (2024) also reported that foliar biomass and leaf area was responsible for alteration of gas exchange parameters found in Manjari Naveen grapevine grafted into different rootstocks.

The effect of different leaf number above the bunch on chlorophyll content in plants was investigated in this study (Figure 1). The results illustrated variations in chlorophyll a, chlorophyll b, and total chlorophyll concentrations across different treatments. Chlorophyll a content in leaf ranged from 28.75 to 32.85 mg ml^{-1} among the treatments. The highest chlorophyll a concentration was observed in the treatment with 10 leaves above bunch (32.85 mg ml^{-1}), followed by the treatment with 12 leaves above the bunch (32.60 mg ml^{-1}). As the leaf numbers increased beyond 12 leaves above bunch, there was a gradual decline in chlorophyll a content, reaching its lowest concentration (>16 leaves above bunch) at 28.75 mg ml^{-1}. Chlorophyll b content also exhibited a similar trend among the treatments. The treatment with 10 leaves above the bunch showed the highest chlorophyll b concentration (12.73 mg ml^{-1}), followed by the treatment with 12 leaves above bunch (12.65 mg ml^{-1}). Subsequent treatments with increasing leaf quantities per shoot displayed a gradual decrease in chlorophyll b content, with the lowest concentration observed in the >16 leaf above bunch (11.40 mg ml^{-1}). Total chlorophyll content, which combines chlorophyll a and chlorophyll b concentrations, emulated the patterns observed in individual chlorophyll types. The treatment with 10 leaves above bunch exhibited the highest total chlorophyll concentration (45.58 mg ml^{-1}), while >16 leaf above bunch treatment displayed the lowest total chlorophyll concentration (40.15 mg ml^{-1}). Petrie et al. (2000) who reported that leaf removal resulted in an increase in, or retention of chlorophyll, which also occurred

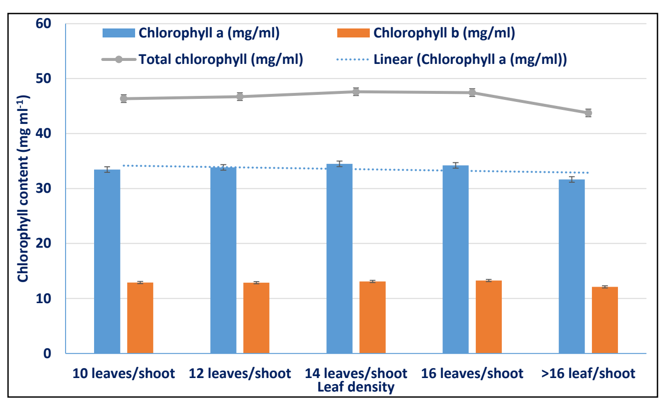

Figure 1: Effect of leaves on chlorophyll content in leaves of Manjari Medika

for the full leaf removal crop treatment. Thoke et al. (2024) reported chlorophyll content ranged from 39.95 to 42.92 at 120 DAP and change in chlorophyll content due to structure of the leaves, including size, thickness, shape and surface area, which affects the distribution of chlorophyll while studying nine different grape varieties. Our results support the findings of Somkuwar et al. (2024c, 2024d and 2024e) reported that beyond optimum leaf number above the bunch (10, 12 and 14 leaves respectively), chlorophyll content per leaf begin to decrease in Crimson Seedless, Manjari Kishmish and Nanasaheb Purple Seedless grape variety.

The correlation studies showed positive relations among various parameters within the parameters (Table 5). Leaf area per leaf exhibits a strong positive correlation with photosynthetically active radiation (PAR) levels (r=0.983) while positive average bunch weight (r=0.968), yield vine^{-1} (r=0.943), juice recovery (r=0.883) and total chlorophyll (r=0.972) in the present investigation indicating importance of factors such as leaf morphology, light availability and chlorophyll content in influencing vine productivity within the vineyard.

Table 5: Correlation coefficients between different growth and yield parameters as influenced by number of leaves maintained above the bunch

parameters	Leaf area leaf^{-1}	Leaf area bunch^{-1} (cm^2)	Leaf area index (m^2 m^{-2})	PAR (µ mol photon m^{-2} S^{-1})	Av. bunch wt. (g)	Yield vine^{-1} (kg)	Juice recovery (%)	Total chlorophyll (mg ml^{-1})
Leaf area leaf^{-1}	1							
Leaf area bunch^{-1} (cm^2)	-0.868	1						
Leaf area index (m^2 m^{-2})	-0.990	0.921	1					
PAR (µ mol photon m^{-2} S^{-1})	0.983	-0.940	-0.991	1				
Av. bunch wt (g)	0.968	-0.777	-0.947	0.922	1			
Yield vine^{-1} (kg)	0.943	-0.741	-0.906	0.901	0.981	1		
Juice recovery (%)	0.833	-0.609	-0.815	0.756	0.941	0.906	1	
Total chlorophyll (mg ml^{-1})	0.972	-0.817	-0.945	0.952	0.971	0.988	0.851	1

4. CONCLUSION

Number of leaves above bunch significantly affects growth, photosynthetic activity, yield, quality, juice recovery of Manjari Medika grape variety. Maintaining 12 leaves above the bunch performed the best, leading to significant improvements in average bunch weight, 50-berry weight, TSS, yield vine^{-1} and juice recovery. It also improved maximum photosynthetic activity and chlorophyll content. However, 12 leaves above the bunch were found sufficient for quality grape and juice production in Manjari Medika grape variety.

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