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Hernandes, José Luiz; Pedro, Mário José
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Yield and grape must quality of the IAC 138-22 'Máximo' submitted to canopy management

José Luiz Hernandes[1], Mário José Pedro Júnior[2]*

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ABSTRACT

Grape cultivar IAC 138-22 'Máximo' grafted on IAC 766 'Campinas' and IAC 572 'Jales' rootstocks and trained in upright trellis was evaluated during consecutive summer and winter growing seasons for comparison different canopy management: a) branch thinning: comparison between one branch and two branches per spur and b) branch tipping: comparison between low and high upright trellis. The results obtained of the phytotechnical and physicochemical grape must characteristics allowed to confirm that there was no significant difference between rootstocks regarding branch thinning intensity and upright trellis height. The largest effect observed in canopy management was for yield values promoted by branch thinning. No effect was observed in the grape must physicochemical characteristics when the different treatments were compared in the same growing season. Regarding to the upright trellis height, larger values of soluble solids were obtained for the high trellis than in the low trellis. Winter growing season resulted in lower values of yield and greater values of total soluble solids and titratable acidity than in the summer growing season.

Keywords: soluble solid content; total acidity; wine grape; extemporaneous pruning.

RESUMO

Produção e qualidade do mosto da uva IAC 138-22 'Máximo' submetida a manejos de dossel

O cultivar de uva IAC 138-22 'Máximo', enxertado sobre IAC 766 'Campinas' e IAC 572 'Jales', sustentado em espaldeira, foi avaliado durante safras consecutivas de verão e de inverno, para se comparar diferentes manejos de dossel: desbrota (comparação entre um e dois ramos por esporão) e desponte (comparação de espaldeiras baixa e alta). Os resultados obtidos das características fitotécnicas e físico-químicas do mosto permitiram verificar que não houve diferença significativa entre os porta-enxertos utilizados, em relação à intensidade de desbrota e à altura da espaldeira. O maior efeito observado pelo manejo de dossel foi nos valores de produção, graças à desbrota, não tendo sido observado efeito nas características físico-químicas do mosto, na comparação dos diferentes tratamentos dentro da mesma safra. Em relação à altura da espaldeira, foram obtidos valores de teor de sólidos solúveis, na espaldeira alta, maiores do que com espaldeira baixa. Foram observados, durante a safra de inverno, valores inferiores de produção e superiores de teor de sólidos solúveis e de acidez titulável total, em relação aos da safra de verão.

Palavras-chave: teor de sólidos solúveis; acidez total; uva para vinho; poda extemporânea.

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[1] Instituto Agronômico (IAC/APTA/SAA), Campinas, São Paulo, Brazil. jlhernandes@iac.sp.gov.br;
[2] Instituto Agronômico (IAC/APTA/SAA), Campinas, São Paulo, Brazil.
CNPq Research Fellow (Processo: 302162/2016-0). mpedro@iac.sp.gov.br
*Corresponding author: jlhernandes@iac.sp.gov.br

INTRODUCTION

The viticulture in the state of São Paulo is basically focused on the production of table grapes, but, vine growers have recently shown an interest in wine grape production as a result of the intensification in agri-tourism. However, because vines are normally grown during the summer season because of the climatic conditions, the maturation and harvesting period occur in December and January, the warm and rainy season, which influences the fruit sugar content and provides a higher occurrence of fungal diseases, resulting in incomplete maturation of grapes (Regina *et al*., 2011; Favero *et al*., 2011).

To overcome this situation, vine growers have used techniques such as extemporaneous pruning and canopy management aiming at improving the quality of the grapes. Regarding wine grapes, the currently most widespread production system combines grapevine cultivation upright trellis, performing pruning in the summer for harvesting in winter, when rainfall is lower, contributing to the obtention of a better product for winemaking purposes (Mota *et al.*, 2010; Regina *et al*., 2011).

Because in the production of fine grapes, the climatological variable has a primordial role in achieving wines of better quality (Regina *et al*., 2011; Dias *et al*., 2017), growers have been using the extemporaneous pruning, performed in January and February, with maturation and harvest between June and August, when rains are scarce, and the thermal amplitude is higher. In these conditions, Dias *et al*., (2012) Favero *et al*. (2011) obtained soluble solids content around 22 ºBrix for Syrah cultivar in the coffee producing region in the state of Minas Gerais.

In the state of São Paulo, at climatic conditions of average altitude in the Jundiaí river basin (700 m), Santos *et al*. (2011a) conducted experiments with Syrah grape cultivar and verified, by the use of extemporaneous pruning, soluble solids contents of 19 ºBrix. Regina *et al*. (2011), in the northeastern region of the state, obtained soluble solids content of up to 25 °Brix. In addition, Santos *et al*. (2011b) reported greater values of Brix at the autumn-winter growing season than in the summer growing season, with values of soluble solids ranging from 15 and 18 °Brix for the rootstocks evaluated for the 'Máximo' cultivar in the region of Jundiaí, state of São Paulo, Brazil. Moreover, Hernandes *et al*. (2016) reported values of about 21 °Brix for 'Syrah' grown in winter harvest regime, in the municipality of Vinhedo, state of São Paulo, Brazil.

The results achieved with cultivar Syrah, both in Minas Gerais and in São Paulo state, and for 'Máximo' grapevine, by the transposition of the growing season to the winter period indicate that, in the Jundiaí region, it would be interesting to combine extemporaneous pruning with canopy management aiming at achieving a greater accumulation of sugars in the grapes.

The purpose of grapevine canopy management is to obtain a balance between vegetative and productive growth, influencing grape maturation (Giovanni & Manfroi, 2009) and to obtain more suitable grapes for wine production (Borghezan *et al*., 2011). Winegrowers by means of practices such as branch thinning and tipping have achieved this balance.

By eliminating unproductive buds, thinning provides a larger use of plant reserves, improving the growth of the selected branches (Mandelli *et al*., 2008).

The tipping on grapevines has been used to limit the vegetative growth of the branches by eliminating the herbaceous part. In Merlot cultivar grapevines grown in the highland region in the state of Santa Catarina, greater soluble solids contents were observed when the ratio between the leaf area (m^2) and the production (kg of grape) varied from 3.0 to 3.4, when using upright trellis with height of about 1.3 m (Brighenti *et al*., 2010). On the other hand, Borghezan *et al*. (2011), also verified for 'Merlot', grown in São Joaquim, Santa Catarina state, little influence of leaf area management on the maturation of the grapes. Similarly, Hernandes *et al*. (2016) verified that tipping, performed on the 'Syrah' grapevine did not influence the soluble solids content. Mota *et al*. (2010), in the region of Caldas, Minas Gerais state, verified that tipping can be recommended for the cultivar Merlot, aiming at improving the concentration of sugars in the grapes. In Serra Gaúcha region, Miele & Mandelli (2012), evaluating different types of green pruning, verified that the combination of thinning, tipping and leaf removal influenced the production components, resulting in less vegetative development of the grapevines, therefore, this combination is indicated for the elaboration of good quality wines.

On account of the advantages in the grape must quality related to the extemporaneous pruning and, possibly, to the canopy management, this experiment was carried out in a vineyard of IAC 138-22 'Máximo' cultivar to evaluate the effect of the branchs thinning and branchs tipping at the yield and physicochemical characteristics to the grapes produced in summer and winter sequential growing seasons.

MATERIAL AND METHODS

The experiment was carried out in a vineyard of IAC 138-22 'Máximo' grapevine cultivar, in the municipality of Jundiaí, SP state, Brazil, at 23º12'S and 46º53' N, about 700 m above sea level. According to the classification of Koeppen, the region is located in a transition area between Cfa for the lower areas and Cfb for the highlands.

The plants were grafted onto the rootstocks IAC-766 'Campinas' and IAC-572 'Jales'. In the vineyard, set at 2 x 1 m spacing, the vines were supported on trellis with wire strands for vertical support of the branches, with bilateral spur cordon.

Phytosanitary treatments to control major fungal diseases; vine management (pruning, removal of secondary buds, removal of shoots, tipping) and fertilization were carried out following the technical recommendation for the region. The winter pruning, carried out during mid-August, was of the short type, maintaining two buds per branch while the extemporaneous pruning, carried out in mid-February, was performed at the height of the second wire of the trellis. Only two buds per branch were stimulated with hydrogen cyanamide at the concentration of 4%.

The experimental design was completely randomized, with four treatments, two different canopy management (branch thinning intensity and height of the trellis) and two rootstocks (IAC 572 'Jales' and IAC 766 'Campinas'), with four replications. The experimental plots consisted of six plants, where the two central ones were considered useful. The treatments related to canopy management were performed, as follows: a) thinning intensity, during 2009 summer and 2010 winter harvests, consisting of the thinning of branches, obtaining one and two branches per spur b) trellis height during the 2010 summer growing season and 2011 winter growing season, consisting of low upright trellis (three wires and vertical branches at height of 0.9 m) and high upright trellis (four wires and vertical branches, at 1.2 m in height), leaving 2 branches per spur.

At harvest, the number of branches per plant, cluster weight (g) and the estimate production per plant were determined by multiplying the clusters number with the average cluster weight. The evaluated variables of the quality of the grape must, extracted by the crushing of the harvested grape berries, considering a ratio of 1: 2: 1 for top, middle and bottom of the cluster, were, as follows: total soluble solids (SS) content; pH and total titratable acidity (TA). Total solid soluble was determined by a digital refractometer (Atago Pal 3) and titratable acidity by titration of the juice with a NaOH 0.1 N standard solution, using pH = 8.2 at titration endpoint. The pH determinations were done in digital pH meter (Digimed DM – 22).

The average values of the phytotechnological parameters of the grapevines (cluster weight, production and number of clusters) and the grape must physicochemical characteristics (soluble solids content and total titratable acidity) were submitted to analysis of variance and the mean values obtained within the same growing season were compared by the Tukey's test. The comparison of the mean values of the different treatments, between the summer and winter growing seasons was made using the t test. The 5% level of significance was adopted for the statistical tests.

RESULTS AND DISCUSSION

The ten-day values of rainfall over the experiment execution are shown in Figure 1.

During the summer growing season, higher rainfall occurred during the maturation-harvesting period (ranging from 280 to 440 mm), particularly affecting the soluble solids content, as observed by Regina *et al*., 2011; Mota *et al*., 2010; Favero *et al*., 2011. On the other hand, the maturation-harvesting season of the winter crops occurred in a regime of lower rainfall values (ranging from 44 to 68 mm), with a consequent promotion in the accumulation of sugars in the grapes.

The results obtained from phytotechnical variables (cluster weight, number of clusters and production per plant) and grape must physicochemical characteristics (soluble solids content and total acidity) of IAC 138-22 'Máximo', on different rootstocks, supported on trellis during summer and winter sequential growing seasons, are presented according to the types of canopy management evaluated: branch thinning and branch tipping (control of the trellis height).

Branch thinning – comparison between one and two branches per spur

During the summer and winter growing seasons, thinning intensity was evaluated for achievement of one branch per spur (1B) and two branches per spur (2B), in order to verify the effects of this type of canopy management on the production and must physicochemical characteristics. During the summer growing season (Table 1), a statistically significant difference was observed for the production and number of clusters between treatments 1B and 2B, as a function of the number of branches left in the plants, and no difference was observed between rootstocks, for the same intensity of thinning.

The average production values varied between 3.53 and 5.96 kg plant^{-1} for the different treatments, probably due to the differences between the numbers of clusters in each treatment. The largest yields obtained in this study were similar to those reported by Hernandes e*t al*. (2010). Regarding cluster weight, no statistical difference was observed for the rootstock used in the study, neither for the number of branches per spur. The observed bunch mass values varied between 143.8 and 164.3 g, considered lower to those reported by Hernandes *et al*. (2010) and greater than those observed by Santos *et al*. (2011b). When considering the physicochemical characteristics of the grape must, no statistical difference was observed in the soluble solids content among the treatments, since the average values of SS were not significantly different by the test of Tukey at 5%, probably because of the high value of LSD (1.67 - Table 1). However, SS values for treatment 2B were larger by about 1 °Brix when compared to those of 1B. Values of SS were, on average, 13.1 °Brix, for treatment 2B, lower than those obtained by Hernandes *et al*. (2010), which were of the order of 17 ºBrix. Regarding total titratable acidity, the values obtained ranged from 130 to 139 mEq L^{-1}. Values of TA close to 120 mEq L^{-1}, as suggested by Rizzon & Miele (2002), are suitable for winemaking.

For the winter crop (Table 1), the same trend was found in the summer growing season, in relation to the phytotechnical characteristics, that is, statistical difference was found between the treatments, for number of clusters but not among the rootstocks, consequently affecting the production of vines. The average production values varied between 1.92 and 3.64 kg $plant^{-1}$, for treatments 1B and 2B, respectively. The largest productions were found for 2R treatment. When average values of cluster weight are compared, no statistical difference was obtained between the treatments, which ranges between 114.9 and 128.7 g. The SS values did not

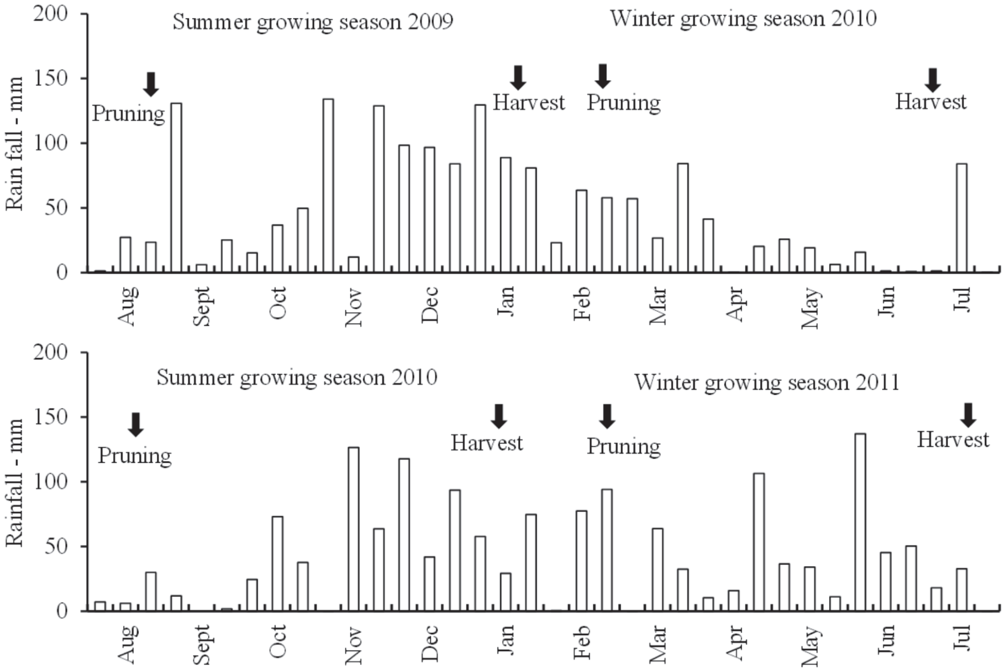

Figure 1: Total rainfall, ten-day period, and indication of pruning and harvesting dates of the IAC 138-22 'Máximo' grape cultivar, grown in sequential summer and winter growing seasons at Jundiaí, São Paulo State, Brazil.

Table 1: Plant variables and grape must physicochemical characteristics of the IAC 138-22 'Máximo', during summer and winter growing seasons for different rootstocks, managed with one and two branches per spur, in Jundiaí, São Paulo State, Brazil

Growing season	Rootstock	Treatment	Yield kg $plant^{-1}$	Number of clusters	Cluster weight - g	S S °Brix	Titratable acidity mEq L^{-1}
	IAC 572	1B	3.53 b	24.6 b	143.8	12.1	142
Summer	IAC 572	2B	5.40 a	37.3 a	145.0	13.1	139
	IAC 766	1B	3.60 b	23.5 b	153.4	12.3	130
	IAC 766	2B	5.96 a	36.8 a	164.3	13.1	131
		LSD	0.87	7.77	25.88	1.67	12.4
		CV (%)	9.1	12.1	8.1	6.3	4.3
	IAC 572	1B	1.92 b	16.8 b	114.9	17.8	150
Winter	IAC 572	2B	3.64 a	28.3 a	128.7	17.8	153
	IAC 766	1B	1.92 b	15.5 b	124.4	17.8	157
	IAC 766	2B	3.02 ab	25.3 a	118.1	17.5	147
		LSD	1.34	6.62	35.6	2.02	16.6
		CV (%)	24.4	14.7	13.9	5.5	5.3

1B = one branch per spur; 2B = two branches per spur; SS= soluble solids. Means followed by the same letter in the column do not statistically differ by the Tukey's test at 5% of probability, for the same growing season differ from each other by the test of Tukey, and they were greater than 17 °Brix, similar to the values reported by Hernandes *et al*. (2010). The values for TA were of the order of 150 mEq L^{-1} and no statistical difference was observed between the treatments.

Branch tipping: comparison between high and low upright trellis

For the subsequent summer and winter growing seasons, two branches per spur were kept. Nevertheless, leaf removal level varied according to the trellis height: low upright trellis (LT) and high upright trellis (HT). Table 2 presents the values of the phytotechnological characteristics of the grapevines and physicochemical characteristics of the must, obtained for sequential summer and winter growing seasons. No statistical difference was observed in the production during the summer growing season among treatments, probably because of the high LSD value (1.45). The yields per plant varied between 3.57 and 4.21 kg $plant^{-1}$. These values are similar to those obtained by Hernandes *et al*. (2010) and greater than those reported by Santos *et al*. (2011b). Bunch mass values did not differ by the test of Tukey and ranged from 242.9 to 270.9 g, greater than those reported by Hernandes e*t al*. (2010) and Santos *et al*. (2011b).

When the physicochemical characteristics of the must were analyzed for the summer growing season, it was verified in the comparison of rootstocks, that the SS values did not differ from each other. On the other hand, in the comparison between the trellis height, a statistical difference was found once the vines trained in high upright trellis showed greater SS values than those of the low upright trellis training at about 1 °Brix. These values were greater probably because of the larger leaf area per plant achieved by the grapevine training in high trellis in comparison to low trellis (25% less). Although several factors are involved in the difference between the values, because of the greater leaf removal of the plants, the high trellis training system may have influenced the greater production and more accumulation of sugars than the rootstock factor.

In relation to the comparison among rootstocks, it was verified that the SS values did not differ from each other in the same treatment, and the total acidity did not show any significant differences between the treatments, ranging from 100 to 110 mEq L^{-1}. These values of total acidity are in the target range of wine grape production (Rizzon & Miele, 2002).

Over the winter growing season (Table 2), no statistical differences were observed for the phytotechnical variables, probably because of the high LSD value (1.14); nevertheless, it was found that production values in high trellis (average of 3.32 kg $plant^{-1}$) were greater than those obtained with the low trellis (average of 2.72 kg $plant^{-1}$). In relation to SS, greater values (18.1 to 18.8 °Brix) were found in the high trellis than those in the low one (17.2 °Brix). No statistical differences were found in the comparison of SS values for rootstocks. Likewise, for the total acidity, no differences were found among the treatments either, with values varying between 150 and 165 mEq L^{-1}.

Comparison between summer and winter growing seasons

Over the winter growing season the yield values achieved by the different canopy management, both for the branch thinning and trellis height, were less than those

Table 2: Plant variables and grape must physicochemical characteristics of the IAC 138-22 'Máximo', during summer and winter growing seasons for different rootstocks, trained with low upright trellis and high upright trellis, in Jundiaí, São Paulo State, Brazil

Growing season	Rootstock	Treatment	Yield kg $plant^{-1}$	Number of bunches	Bunch weight - g	Soluble solids °Brix	Titratable acidity mEq L^{-1}
Summer	IAC 572	HT	4.14	16.7	247.9	14.9 a	107
	IAC 572	LT	3.57	14.6	246.3	13.6 b	111
	IAC 766	HT	4.21	15.6	270.9	14.7 a	100
	IAC 766	LT	3.60	13.6	242.9	13.2 b	110
		LSD	1.45	5.08	43.1	1.06	14.6
		CV (%)	17.8	15.9	8.2	5.6	6.3
Winter	IAC 572	HT	3.17	18.0	176.7	18.1 a	165
	IAC 572	LT	2.70	15.6	177.2	17.2 b	153
	IAC 766	HT	3.47	19.3	179.5	18.8 a	150
	IAC 766	LT	2.74	15.9	173.6	17.2 b	159
		LSD	1.14	6.27	46.2	0.77	29.2
		CV (%)	18.1	17.4	12.4	1.3	8.9

LT = low upright trellis; HT= high upright trellis. Means followed by the same letter in the column do not statistically differ, by the Tukey's test at 5% of probability, for the same growing season.

Table 3: Comparison of plant variables, for summer and winter growing seasons, of the IAC 138-22 'Máximo' grape cultivar submitted to different canopy management systems

Rootstock	Treatment	Yield – kg plant^{-1}			Number of clusters			Cluster weight- g		
		DT	LS	CSW	DT	LS	CSW	DT	LS	CSW
IAC 572	1 B	1.61	*	S > W	7.9	*	S > W	28.9	*	S > W
IAC 572	2 B	1.76	*	S > W	9.0	*	S > W	16.3	*	S > W
IAC 766	1 B	1.68	*	S > W	8.0	*	S > W	29.0	*	S > W
IAC 766	2 B	2.94	*	S > W	11.5	*	S > W	46.2	*	S > W
IAC 572	HT	0.97	*	S > W	1.2	ns	S = W	71.2	*	S > W
IAC 572	LT	0.87	*	S > W	1.2	ns	S = W	69.1	*	S > W
IAC 766	HT	0.74	*	S > W	3.6	ns	S = W	91.4	*	S > W
IAC 766	LT	0.86	*	S > W	2.2	ns	S = W	69.3	*	S > W

1B = one branch per spur; 2B = two branches per spur; HT = high upright trellis; LT = low upright trellis; S= summer growing season; W = winter growing season; DT = Difference between treatments; LS = Level of significance; CSW = comparison between summer and winter growing seasons; ns = not significant; * = significant at 5% by the "t" test.

Table 4: Comparison of grape must physicochemical characteristics, for summer and winter growing seasons, of the IAC 138-22 'Máximo' submitted to different canopy management systems

Rootstock	Treatment	Soluble solids - °Brix			Titratable acidity – mEq L^{-1}		
		DT	LS	CSW	DT	LS	CSW
IAC 572	1 B	5.7	*	S < W	11	*	S < W
IAC 572	2 B	4.7	*	S < W	14	*	S < W
IAC 766	1 B	5.6	*	S < W	27	*	S < W
IAC 766	2 B	4.4	*	S < W	16	*	S < W
IAC 572	HT	3.2	*	S < W	58	*	S < W
IAC 572	LT	3.7	*	S < W	43	*	S < W
IAC 766	HT	4.1	*	S < W	40	*	S < W
IAC 766	LT	4.0	*	S < W	49	*	S < W

1B = one branch per spur; 2B = two branches per spur; HT = high upright trellis; LT = low upright trellis; S = summer growing season; W = winter growing season; DT = Difference between treatments; LS = Level of significance; CSW = comparison between summer and winter growing seasons; ns = not significant; * = significant at 5% by the "t" test.

of the summer growing season. This effect is probably due the smaller cluster weight as no difference was found among number of clusters in trellis height training system when summer and winter growing seasons were compared (Table 3). Regarding thinning, the yields obtained in the winter growing season were, on average, 1.99 kg plant^{-1}, less than the summer growing season while for the trellis height training, the yields achieved with IAC 138-22 'Máximo' were 0.86 kg plant^{-1} on average, lower during the winter growing season, in comparison to those of the summer growing season.

In relation to SS, a statistical difference between the summer and winter growing seasons is confirmed (Table 4), and the values of the winter growing season were greater, around 4 °Brix, than those of the summer growing season. During the winter growing season, SS values reached about 18 °Brix, probably caused by the lower occurrence of rainfall during the maturation period, allowing a greater accumulation of sugars (Santos *et al*., 2011b, Regina *et al*., 2011; Favero *et al*., 2011). A larger value for total acidity was confirmed during the winter growing season, reaching an average of 156 mEq L^{-1}, in comparison with 105 mEq L^{-1}, for the summer growing season.

CONCLUSIONS

When the same growing season is considered, the different rootstocks did not present differences for the evaluated parameters of production and quality, while the branch thinning influenced the production, but did not interfere in the bunch mass, the in the soluble solids content and in the total acidity.

Trellis height had no influence on the production, on the cluster weight and on the total acidity; however, greater values of soluble solids content were presented by the high trellis.

In the summer growing season, the production values and cluster weight were greater, and the soluble solids and total acidity contents were less than those of the winter growing season.

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