YIELD AND SUGAR ACCUMULATING CAPACITIES OF AIRÉN CULTIVAR. A PRELIMINARY STUDY

POTENTIEL DE PRODUCTION ET ACCUMULATION DE SUCRE DE CÉPAGE AIRÉN. UNE ÉTUDE PRÉLIMINAIRE

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Abstract

Airén is the most worldwide spread white grape cultivar, high yielding, well adapted to hot, dry conditions, and not very sensitive to fungal diseases. Its largest growing region is La Mancha, where Airén has been traditionally bush trained, spur pruned and grown with no irrigation. However, grape growing has evolved to meet the need for higher yields and harvest mechanization; and modern cultural practices train grape vines to simple multi-wire trellis systems, cane pruned, and usually irrigated. The aim of the present study was to evaluate the yield and sugar accumulating capacities of Airén cultivar with regard to leaf area, and to assess the influence that different yield components have on yield. In 2014, five commercial irrigated vineyards, located in La Mancha, of different ages, and grafted onto different rootstocks were selected for this study. Canopy surface area (SA) was measured at maturity. Berry weight and sugar concentration were measured during ripening on a weekly basis. Yield and yield components were determined at harvest. Values for shoot density ranged 2.3-5.1 shoots/m^2; SA, 0.6-1.1 m^2/m^2; yield, 20-40 t/ha; fertility, 1.1-1.7 bunches/shoot; bunch weight, 450-650 g; berry weight, 2.5-2.9 g; and sugar concentration, 17-21 ºBrix. The number of bunches per shoot was the yield component that had the greatest influence on yield. The number of berries was the main contributing factor to bunch weight. A lineal relationship between SA/yield and sugar concentration was observed, with values of SA/yield ranging from 0.20 to 0.45 m^2/kg. A ratio SA/yield of approximately 0.4 m^2/kg was needed to reach a value of 20 ºBrix. Hence it would be necessary a SA of 12000 m^2/ha, under the conditions of this study, to achieve a 30 t/ha yield, and a sugar concentration of 20 ºBrix. These results are a step forward in the study of the Airén cultivar, being of help for grape growers in the center area of Spain in order to maximize crop yield and sugar accumulation.

Keywords : *cv Airén, La-Mancha region, yield components, sugar content, canopy surface area.*

Resumé

Airén est le cépage blanc la plus cultivée dans le monde, à haut rendement, bien adaptés aux conditions chaudes et sèches, et peu sensible aux maladies fongiques. Sa plus grande région est La Mancha, où les vignes ont été formées dans les gobelets, avec taille courte, et cultivé sans irrigation. Toutefois, la viticulture a évolué pour répondre aux besoins des rendements plus élevés et mécanisation de la vendange; et les pratiques culturelles modernes former vignes aux systèmes de conduite type espalier, avec taille longue, et habituellement irriguées. Le but de la présente étude était d'évaluer les capacités de rendement et de sucre accumulation du cépage Airén à l'égard de la surface foliaire, et d'évaluer l'influence que les différentes composantes du rendement ont sur le rendement. En 2014, cinq vignobles irrigués commerciales, situées à La Mancha, d'âges différents, et greffés sur des porte-greffes différents ont été sélectionnés pour cette étude. La surface externe du couvert végétal (SA) a été mesurée à la période de maturation. Le poids des baies et le teneur de sucre a été mesurée pendant la maturation. Le rendement et ses composantes ont été déterminés lors de la vendange. Les valeurs de densité de rameaux allaient 2.3 à 5.1 rameaux/m^2; SA, 0.6-1.1 m^2/m^2; rendement, 20-40 t/ha; la fertilité, 1.1-1.7 grappes/rameaux; le poids de la grappe, 450-650 g; poids des baies, 2.5-2.9 g; et le teneur de sucre, de 17-21 ºBrix. Le nombre de grappes par rameaux était la composante du rendement qui a eu la plus grande influence sur le rendement. Le nombre de baies a été le principal facteur contribuant à poids de la grappe. Une relation linéaire entre SA/rendement et le teneur de sucre a été observée, avec des valeurs de SA/rendement allant de 0.20 à 0.45 m^2/kg. Un rapport SA/rendement d'environ 0.4 m^2/kg était nécessaire pour atteindre une valeur de 20 ºBrix. Il serait donc nécessaire, une SA de 12000 m^2/ha, dans les conditions de cette étude, pour atteindre un rendement de 30 t/ha, et une teneur de sucre de 20 ºBrix. Ces résultats sont un pas en avant dans l'étude du cépage Airén, étant d'aide pour les producteurs dans la zone centre de l'Espagne afin de maximiser le rendement et de l'accumulation de sucre.

Mots-clés : cv Airén, région de La-Mancha, composantes du rendement, teneur en sucre, surface externe du couvert végétal.

1. Introduction

Airén is the most worldwide spread white grape cultivar, and it is well adapted to the Spanish region of La Mancha, its largest growing region. The need for increasing profitability has led the grapegrowers to convert their bush-trained, spur pruned, non-irrigated vineyards into trellis-supported, cane pruned, irrigated ones. High yields and sugar concentration values are the main production targets of Airén as this cultivar is not meant for production of high quality wines but economic ones, juices, or even for distilling. In fact, grape prices (€/kg) for this cultivar are usually fixed according to probable alcohol content only. In order to optimize yield, it is necessary to understand the relative importance of each of its components, as well as how and why they may fluctuate. Normally, compare to bunch weight, the number of bunches per vine has a greater influence on yield variability over space and time (Dry, 2000). Sugar accumulation is determined to a great extent by the balance between fruit yield and vegetative growth (Howell, 2001). Generally, 7-14 cm^2 of leaf per gram of fruit are needed to assure grape maturity (Kliewer and Dokoozlian, 2005) although, for a set value, the ripeness level may vary depending on environmental conditions as well as leaf and bunch distribution, that is determined by the training system (Jackson and Lombard, 1993; Reynolds and Vanden Heuvel, 2009). The aim of this preliminary study was to understand the source of yield variability on irrigated vineyards of Airén cultivar, and to assess the effect that the leaf/fruit ratio has on sugar accumulation.

2. Materials and methods

Experimental vineyards

The study was carried out during 2014, in five commercial Airén vineyards, located in the region of La Mancha, in the areas of Pedro Muñoz (Ciudad Real; 39º 27' N, 3º 0' W, 665-670 m amsl) and Los Hinojosos (Cuenca; 40º 8' N, 3º 23' W, 730 m amsl). The climate of this area is mild, with warm, dry summers (Mediterranean climate). In 2014, from 1st April until 31st October, rainfall of 59 mm and 2075 GDD (growing degree days, base 10 ºC) were registered. The most representative soils of the region are Xerochrept. They are deep soils, with low content of organic matter, slightly acid pH, and sandy-loam texture. Location, rootstocks, planting distances, and planting years for each vineyard are detailed in table 1.

Vines were head trained at a 0.8-1.0 m, and cane pruned (bilateral Guyot). Foliage was trained upwards by a pair of wires located at 0.15-0.30 m above the fruiting wire. Weeds were kept under control by tillage. According to the grapegrowers criteria, vineyards were drip irrigated 3-4 times from berry set to veraison. Each irrigation event lasted 48 hours approximately. The amounts of water provided by watering to each vineyard (numbers 1 to 5) were of 2750, 1475, 2750, 2750 and 2300 m^3/ha, respectively.

Four replications were set up in each of the vineyards, with each replication having ten plants from a single row taken into account for data acquisition.

Experimental design and measurements

a) Canopy characterization. Measurements of canopy surface area (SA, m^2/vine) were taken at ripening. SA was determined using geometric calculations in three plants per replicate, having into consideration the sum of the height of both vertical sides of the canopy plus the length of the semicircular upper section.

b) Berry weight and composition. One sample of 100 berries was collected per replicate on a weekly basis, from veraison to harvest. The 100-berry samples were weighed and the must total soluble solids (ºBrix) content was determined using a refractometer (PR32 Atago Co. Ltd., Tokyo, Japan).

c) Yield components. The number of bunches and shoots, and the crop yield at harvest were recorded for 10 vines per replicate. The number of bunches per shoot was calculated as the number of bunches/total number of shoots. The average bunch weight was obtained by dividing the total yield by the total number of bunches. The number of berries per bunch was determined as average bunch weight/berry weight (berries sampled for must composition).

Data analysis

Per variable and vineyard, average and standard deviation values of the four repetitions are presented. Linear regression analysis was used to explore the relationship between the different variables studied. Statistical analyses were performed using SPSS v15.0 (SPSS Inc, Chicago, Illinois, USA).

3. Results and discussion

All vineyards under study had some common characteristics, these being the Airén cultivar, the training system and the irrigation system. Inter-row distances were similar, ranging from 2.5 to 2.8 m, whereas in-row distances presented a wider variability, ranging from 1.3 to 2.5 m (table 1). Aged vineyards, transformed from bush to multi-wire trellis system, had bigger distances between vines.

Table 1. *Characteristics of the experimental vineyards.*

Tableau 1. Caractéristiques des vignobles expérimentaux.

Vineyard Nº	Municipality	Planting year	Rootstock	Inter-row distance (m)	In-row distance (m)
1	Pedro Muñoz	2011	110R	2.8	1.3
2	Pedro Muñoz	1983	110R	2.6	2.5
3	Pedro Muñoz	2011	110R	2.8	1.3
4	Los Hinojosos	2006	1103P	2.8	1.3
5	Pedro Muñoz	1994	41B	2.5	2.5

Among the studied vineyards, shoot density ranged from 2.3 to 5.1 shoots/m^2; fertility, from 1.1 to 1.7 bunches/shoot; bunch weight, from 450 to 650 g; berry weight, from 2.5 to 2.9 g; and crop yield, from 20 to 40 t/ha (table 2).

Table 2. *Crop yield and yield components.*

Tableau 2. Rendement et les composantes du rendement.

Vineyard Nº	Crop yield (t/ha)	Shoots/m²	Bunches/shoot	Bunch weight (g)	Berries/bunch	Berry weight (g)
1	21.2 ± 3.9	3.9 ± 0.6	1.2 ± 0.1	566 ± 213	167 ± 57	2.9 ± 0.1
2	20.3 ± 0.4	2.6 ± 0.2	1.5 ± 0.1	790 ± 87	206 ± 22	2.6 ± 0.3
3	23.6 ± 3.8	4.6 ± 0.3	1.4 ± 0.2	515 ± 93	154 ± 29	2.5 ± 0.3
4	40.9 ± 2.5	4.9 ± 0.2	1.7 ± 0.1	832 ± 57	171 ± 11	2.8 ± 0.1
5	28.5 ± 2.7	3.1 ± 0.5	1.5 ± 0.1	920 ± 89	222 ± 22	2.8 ± 0.1

Note : Mean value and standard deviation presented.

The number of bunches per shoot was the yield component that influenced crop yield the most (R^2=0.75, figure 1).

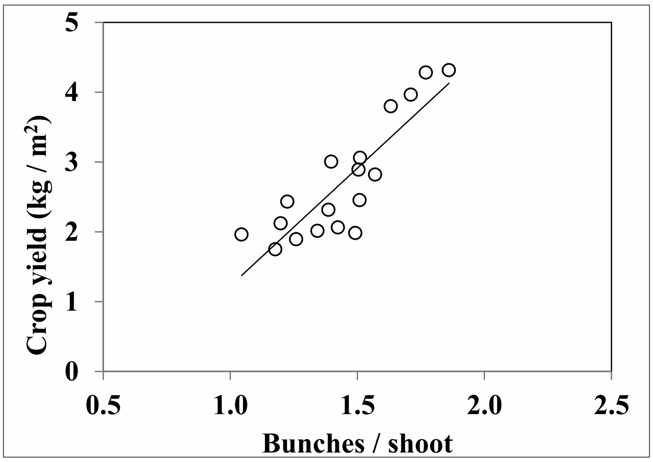

Figure 1. Relationship between crop yield and bunches/shoot (y = 3.3748 x – 2.15; R^2 = 0.75**; n = 18).

Figure 1. Relation entre le rendement et grappes/rameaux (y = 3.3748 x – 2.15; R^2 = 0.75**; n = 18).

Shoot density and bunch weight did not show a great effect on yield variation (R^2=0.25 and R^2=0.03 respectively, data not shown). Bunch weight was mostly dependent on the number of berries (R^2=0.83, figure 2), and not on berry weight (R^2=0.03, data not shown). Under the conditions of this study, fertility (number of bunches per shoot) was a determining factor on final yield. Hence previous year conditions seemed to play a crucial role on yield formation. The maintenance of an intense activity, and appropriate light conditions were seen to be key factors for floral differentiation. Studies such as the ones made by Smart (1985), Dry (2000) y Carmo Vasconcelos *et al*. (2009) highlighted the importance of light and carbohydrate accumulation on fertility.

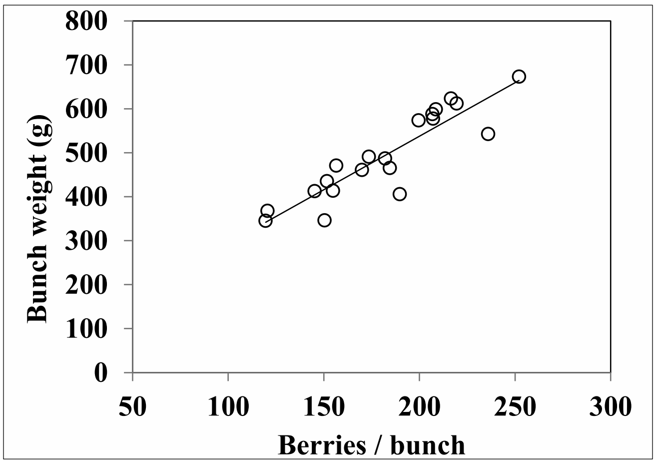

Figure 2. *Relationship between bunch weight and berries/bunch (y = 2.4836 x + 42.24; R^2 = 0.83**; n = 20).*

Figure 2. Relation entre le poids de la grappe et baies/grappe (y = 2.4836 x + 42.24; R^2 = 0.83**; n = 20).

Vineyards under study had SA ranging from 0.6 to 1.1 m^2/m^2; crop yield, from 20 to 40 t/ha; and sugar concentration, from 17 to 21 ºBrix (table 3).

Table 3. Leaf/fruit ratio and sugar accumulation.

Tableau 3. Rapport feuilles/fruit et accumulation de sucres.

Vineyard nº	SA (m^2/m^2)	Crop yield (t/ha)	SA / Yield (m^2/kg)	TSS (ºBrix)	Sugar yield (t sugar/ha)
1	0.77 ± 0.10	21.2 ± 3.9	0.37 ± 0.05	20.7 ± 0.5	4.2 ± 0.6
2	0.74 ± 0.07	20.3 ± 0.4	0.37 ± 0.03	18.9 ± 0.4	3.9 ± 0.1
3	0.70 ± 0.07	23.6 ± 3.8	0.30 ± 0.05	17.7 ± 0.3	4.2 ± 0.7
4	0.95 ± 0.14	40.9 ± 2.5	0.23 ± 0.02	17.1 ± 0.6	7.0 ± 0.5
5	0.89 ± 0.08	28.5 ± 2.7	0.32 ± 0.06	17.6 ± 0.5	5.0 ± 0.5

Note : Mean value and standard deviation presented.

A linear relationship between SA/yield and sugar concentration was observed, with values of SA/yield ranging from 0.20 to 0.45 m^2/kg (figure 3).

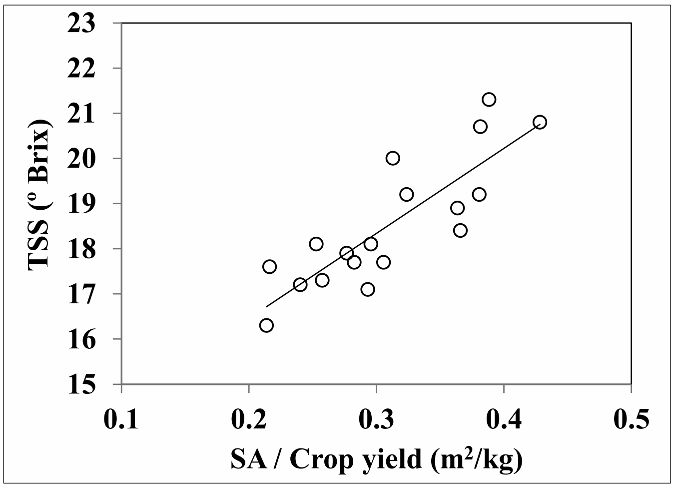

Figure 3. *Relationship between sugar concentration (TSS) and SA/Crop yield (y = 18.824 x + 12.693; R^2 = 0.71**; n = 18).*

Figure 3. Relation entre la teneur en sucre (TSS) et le rapport surface externe du couvert végétal/rendement (y = 18.824 x + 12.693; R^2 = 0.71**; n = 18).

According to this correlation, under the conditions of this study, a SA/yield ratio of approximately 0.4 m^2/kg would be needed in order to reach a sugar concentration in the must of 20 ºBrix. In other words, to aim 20 ºBrix in the must, SA values of 8000, 10000 and 12000 m^2/ha would be needed for crop yields of 20, 25 and 30 t/ha, respectively. These values are noticeably lower to what other authors have previously found necessary (0.7-1.4 m^2 leaf area per kg of fruit) to reach adequate grape compositions at harvest (Kliewer and Dokoozlian, 2005). However, it should be noted that the grapes produced in our experiments are meant for economic table wines, some of them used in distillation for alcohol production.

4. Conclusion

The present study shows preliminary data on the productive capacity of irrigated vineyards of Airén cultivar, trained on multi-wire trellis systems. Under these conditions, the number of bunches per shoot was the yield component that showed the greatest effect on yield variability. 0.4 m^2 of canopy surface area per kg of fruit were needed in order to reach 20 ºBrix.

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