Vegetative growth and quality of grapevine 'Chenin blanc' irrigated under three pan evaporation coefficients

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Abstract — Introduction. Winegrape (*Vitis vinifera* L.) production in Venezuela occurs in semiarid regions in order to achieve good control of fungal diseases. Under these conditions, trickle irrigation is mainly used due to the high water cost. The purpose of this study was to determine the minimum drip irrigation volumes compatible with grape yield and quality. **Materials and methods**. Four-year old plants cv. Chenin blanc were drip irrigated under pan evaporation coefficients of 0.1, 0.2, and 0.4 in the semiarid zone of Altagracia, Lara state, Venezuela. The experimental design was a randomized complete block with nine plants per irrigation treatment. **Results and discussion**. Leaf water potentials at flowering, midseason and veraison averaged values of –0.40, –0.34 and –0.28 MPa for pan coeffients of 0.1, 0.2, and 0.4, respectively, which resulted in a concomitant increase of the total shoot length (80.6, 104.3 and 172.5 cm). Mean grape yield, although quite variable among plants, was highest in the wettest treatment. The different irrigation regimes affected the overall fruit quality. **Conclusion**. Lower irrigation volumes consistently decreased fruit acidity and plant shoot growth. The use of pan evaporation coefficients lower than 0.40 (0.47 including rainfall) is not advisable. (© Elsevier, Paris)

Venezuela / *Vitis vinifera* / water potential / trickle irrigation / quality / growth

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Croissance végétative et qualité du raisin Chenin blanc irrigué selon trois valeurs du coefficient de conversion d'un bac évaporatoire (ccbe).

Résumé — Introduction. La production de raisin (*Vitis vinifera* L.) au Venezuela se fait en zones semi-arides afin d'éviter les maladies fongiques. Dans ces conditions, la technique d'irrigation la plus utilisée est celle du goutte-à-goutte qui limite les coûts en eau. Cette étude a cherché à déterminer des plus bas volumes d'irrigation permettant d'assurer le rendement et la qualité du raisin. **Matériel et méthodes**. Des plants du cultivar Chenin blanc, âgés de 4 ans et cultivés dans la région semi-aride de Altagracia, Lara state, Venezuela, ont été irrigués au goutte-à-goute en utilisant des ccbe de 0,1, 0,2, et 0,4. Le dispositif expérimental était en blocs randomisés de neuf plants par traitement d'irrigation. **Résultats et discussion**. Les potentiels hydriques des feuilles aux stades floraison, mi-saison et véraison ont atteint, en moyenne, les valeurs –0,40, –0,34 et –0,28 MPa, pour, respectivement, les ccbe de 0,1, 0,2, et 0,4 ; cela a été accompagné d'un accroissement des tiges de 80,6, 104,3 et 172,5 cm. Les rendements moyens, bien que variables d'un plant à l'autre, ont été les plus forts pour le traitement le plus irrigué. Les différents régimes d'irrigation ont affecté la qualité globale du fruit. **Conclusion**. Les bas volumes d'irrigation ont diminué significativement l'acidité du fruit et la croissance des plants. L'utilisation de ccbe inférieurs à 0,40 (0,47 en incluant les précipitations) n'est pas recommandée. (© Elsevier, Paris)

Venezuela / *Vitis vinifera* / potentiel hydrique / irrigation goutte-à-goutte / qualité / croissance

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1. introduction

Wine grape production in Venezuela has been increasing since last decade. Main production areas are located in semiarid regions in order to avoid fungal diseases that seriously affect the plants in humid tropics. In these regions, irrigation becomes a mandatory management practice.

In the grape productive areas of the country, the high cost of irrigation water, mainly obtained from wells, greatly justifies the use of drip systems [1], and, in order to maximize the water saving, pan evaporation methods for irrigation scheduling [2] are encouraged among growers.

The main objective of this paper was to determine the lower pan evaporation coefficients that growers should utilize without seriously affecting the crop yield and quality of the grapevine cv. Chenin blanc in the zone of Altagracia, Venezuela.

2. materials and methods

The experimental site was a 80-ha vineyard (*Vitis vinifera* L.) cv. Chenin blanc, located near the Altagracia town, Lara state, Venezuela, at 10º 21' N, 479 m asl. The soil is a loam to sandy loam, isolated within a region characterized by poor, very heavy soils.

Vines, 4-year old, are grafted on the native rootstock Criolla Negra and trained as bilateral single cordon 0.80 m high with upper catch wire 1.60 m above the soil. The vineyard was kept clean cultivated and had a plant spacing of 3.0 × 1.2 m. The drip irrigation system consisted of a single lateral with one 3 $L \cdot h^{-1}$ dripper per plant.

Irrigation treatments consisted in three class A pan evaporation coefficients, viz. 0.1 (k_1), 0.2 (k_2) and 0.4 (k_3), calculated on the basis of 3.6 m^2 planting area. The mean weekly value of pan evaporation was obtained from the previous week evaporation, and the different volumes of applied water were achieved by varying the time for functioning of drippers. Irrigations were applied early in the morning and this regime was maintained from budbreak to completion of harvest.

The experimental design was a randomized complete block with three irrigation treatments, three replications and three plants per plot.

Predawn leaf water potential (LWP) was determined just before irrigation using a Scholander pressure bomb at phases of flowering, i.e., 31 d after pruning (31 dap), midseason (74 dap) and veraison (91 dap) using three recently fully developed leaves per plot.

Shoot length was measured at weekly intervals, starting three weeks after pruning and ending 12 d before harvest, using six shoots randomly selected per plot. Total yield was measured on the three vines of the plot. Total soluble solids, titratable acidity, and pH were determined on nine bunches randomly selected per plot.

The data were subjected to analysis of variance followed by Duncan's multiple range tests using the statistical package Cohort2 (Costat. Berkeley, California, version 4.21).

3. results and discussion

3.1. water volumes

Plants in each irrigation treatment received, including 86 mm of effective rainfall, 216, 346, and 606 mm of water for k_1, k_2 and k_3, respectively (*table I*). The lower pan evaporation coefficients resulted in a lower amount of total irrigation water.

3.2. leaf water potential

Predawn LWP decreased as the irrigation volumes were lower, regardless of the growth period, averaging values of –0.40, –0.34 and –0.28 MPa for k_1, k_2 and k_3, respectively (*table II*). The differences between the driest and the wettest plants were increasing as the growth period went from flowering and midseason to veraison, showing values of 0.07, 0.14, and 0.21 MPa, respectively. On the other hand, LWP averaged lower absolute values at the phase of veraison as compared to earlier phases, perhaps reflecting a larger depletion of the overall soil water by plants in continuous growth that were receiving constant volumes of irrigation. Pickering [3] found comparative results at the end of the growth period, which were attributed to salt accumulation and insufficient irrigation volumes to satisfy an increased water demand of plants.

3.3. shoot growth

The elongation rate of shoots was very sensitive to changes in irrigation water volumes (*figure 1*). Although the pattern of growth at the beginning followed a similar trend, with rapid initial shoot elongation, plants under the lowest pan coefficients ceased shoot growth at about 45 dap, averaging a rate of 1.8 $cm \cdot d^{-1}$. Plants under the intermediate pan coefficient showed a decrease of the elongation rate at 51 dap, averaging 1.8 $cm \cdot d^{-1}$, and slowing down thereafter to 0.3 $cm \cdot d^{-1}$ untill a few days before veraison. Plants under the highest pan coefficient showed a continuous shoot elongation throughout almost the entire season averaging 2.0 $cm \cdot d^{-1}$ as initial growth rate, and decreasing after veraison.

The total accumulated shoot length at 108 dap was 80.6, 104.3 and 172.5 cm for k_1, k_2 and k_3, respectively. The shoot length at phases of bloom, midseason and veraison were in close agreement with predawn LWP (*table II*; *figure 1*), showing that shoot length was consistently higher as LWP was higher. Similar results have already been published [4–7]. These effects of irrigation on shoot growth are probably mediated by its effects on cell turgor [8].

3.4. yield and fruit quality

Mean grape yield was highest in the wettest treatment (*table III*). However, the results were not consistent among treatments, which could be partially explained by the high variability frequently found in young vines grown under tropical conditions.

Table I.
Total water volumes received by grapevines 'Chenin blanc' as a function of the irrigation regime and rainfall.
Rainfall and evaporation were 86 mm and 1 302 mm, respectively.

Treatment	Pan coefficient	Irrigation[1] (mm)	Total water[2] (mm)
K_1	0.1	130	216
K_2	0.2	260	346
K_3	0.4	520	606

[1] : Irrigation = Pan coefficient × evaporation.
[2] : Total water = irrigation + rainfall.

Table II.
Predawn leaf water potential (LWP) of grapevine 'Chenin blanc' as a function of pan evaporation coefficients and phases of growth.

Pan coefficient	Leaf water potential (-MPa)		
	Bloom	Midseason	Veraison[1]
0.1	0.35[a]	0.29[a]	0.56[a]
0.2	0.31[b]	0.27[b]	0.45[ab]
0.4	0.28[c]	0.20[c]	0.35[b]
Test significance	*	*	*
CV	2.80	2.27	7.24

[1] Data transformed by square root for veraison.
a, b, c : in a same column, homogeneous group according to the Duncan's multiple range test (p = 0.05).

Overall, higher irrigation volumes tended to reduce total soluble solids (*table III*). Smart and Coombe [9] and Williams et al. [7] mention that sugar accumulation is less affected by water deficits than berry growth, so the effect maybe associated to solute concentration. However, the overall increase of yield in the wettest treatment seems to have surpassed by far the increase of sugar concentration in the driest one, thus rendering higher weight of sugar produced per plant.

Total acidity was consistently lower in the less irrigated treatments (*table III*). That maybe an indirect effect of a decreased vegetative growth (*figure 1*) because fruit shading by leaves is more likely for vines that are well supplied with water. Shading

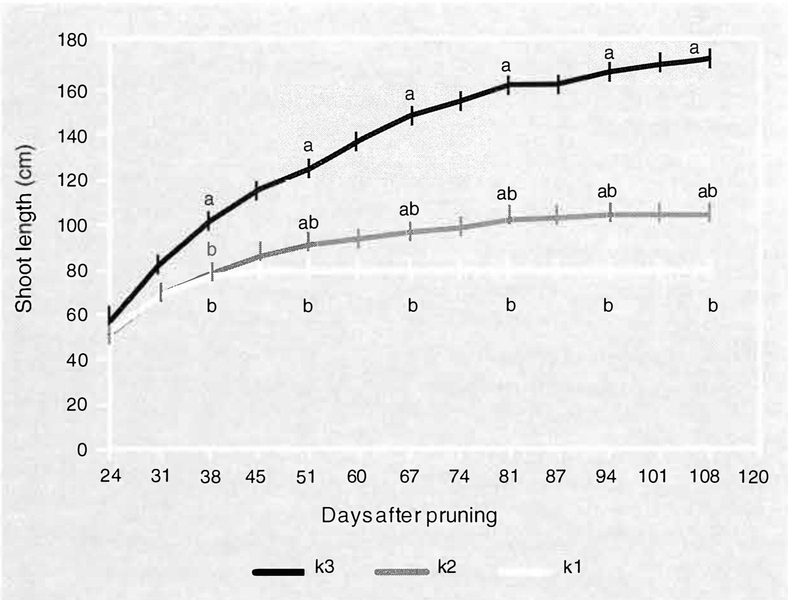

Figure 1.
Shoot growth of grapevine 'Chenin blanc' as a function of irrigation under three pan evaporation coefficients (k_1, 0.1; k_2, 0.2; k_3, 0.4). Budbreak at day 9 after pruning; harvest at day 120. Mean separation within selected days by Duncan's multiple range test (p = 0.05).

reduces the rate of respiration of malic acid due to lower temperatures in bunches [9].

The pH was little affected by irrigation even though mean values followed a decreasing trend (*table III*). The overall plant performance showed that the highest irrigation volume (pan coefficient of 0.4) resulted in better vine growth, higher yield and lower TSS concentration. The TSS accumulation per plant, however, was higher.

Table III.
Yield and quality of grape 'Chenin blanc' as a function of pan evaporation coefficients.

Pan coefficient	Yield ($kg \cdot ha^{-1}$)	Total soluble solids (°Brix)	Total acidity ($g \cdot 100\ mL^{-1}$ tartaric acid)	pH
0.1	3123	20.8	0.19^{b}	3.40
0.2	2 831	19.8	0.26^{a}	3.30
0.4	5 460	19.5	0.27^{a}	3.13
Test significance	ns	ns	*	ns
CV	17.76	3.07	7.58	3.66

a, b, c: in a same column, homogeneous group according to the Duncan's multiple range test (p = 0.05).
ns: not significative differences.

Hepner et al. [5] found better vine growth when using coefficients of 0.45 as compared to 0.27 in Israel, and Smart et al. [10] reported a coefficient of 0.40 at Griffith, Australia. Likewise, this pan coefficient is in good agreement with the average crop coefficients for winegrapes shown by Allen et al. [11] under full canopy conditions and those reported by Tsanis et al. [12] in southern Greece.

In the commercial part of the vineyard, close to the experimental site, the volume of water applied approached an overall pan coefficient of 0.6 and the average plant yield was 5 940 $kg \cdot ha^{-1}$ [13]. Since that yield is not much higher than the yield found in the wettest treatment (5 460 $kg \cdot ha^{-1}$), it may indicate that, for water saving purposes, the best benefits from drip irrigation could be obtained by using pan coefficients around 0.4.

The scheduling of trickle irrigation by using pan coefficients is somewhat complicated by the effective rainfall that may occur [2]. In this paper, the effective rainfall was estimated to be above 5 mm, thus ignoring a few very short drizzles that occurred during the growing period. Hence, when considering the total volumes of water received by the plants, i.e., irrigation plus effective rainfall (*table I*), the best overall pan coefficient would become 0.47 (606 mm divided by 1302 mm).

4. conclusion

Lower irrigation volumes consistently decreased fruit acidity and plant shoot growth. The highest water volume resulted in the highest yield. Using pan evaporation coefficients lower than 0.4 is not advisable.

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Crecimiento vegetativo y calidad de la uva 'Chenin blanc' irrigada con tres valores de coeficiente de conversión de una cubeta de evaporación (ccce).

Resumen — Introducción. En Venezuela, se produce uva (*Vitis vinifera* L.) en zonas semi-aridas para evitar las enfermedades fungicas. En estas condiciones, la técnica de riego más utilizada es la del gota-a-gota que limita los costos de agua. Este estudio intentó determinar los volúmenes de riego más bajos que permitieran asegurar el rendimiento y la calidad de la uva. **Material y métodos**. Plantas del cultivar Chenin blanc, de 4 años de edad y cultivadas en la región semi-arida de Altagracia, estado Lara, Venezuela, fueron irrigados con gota-a-gota al utilizar ccce de 0,1, 0,2, y 0,4. El dispositivo experimental era en bloques al azar con nueve plantas por tratamiento de riego. **Resultados y discusión**. Los potenciales hídricos de las hojas en las fases floración, mitad-temporada y envero alcanzaron, por término medio, los valores –0,40, –0,34 y –0,28 MPa, para los ccce de 0,1, 0,2, y 0,4, respectivamente; esto fue acompañado con un incremento de la longitud de los tallos de 80,6, 104,3 y 172,5 cm. Los rendimientos medios, aunque variables de una planta a otra, fueron más fuertes para el tratamiento más irrigado. Los distintos regímenes de riego afectaron la calidad global del fruto. **Conclusión**. Los bajos volúmenes de riego disminuyeron significativamente la acidez del fruto y el crecimiento de las plantas. No se recomienda utilizar (ccce) inferiores a 0,40 (0,47 al incluir las precipitaciones). (© Elsevier, Paris)

Venezuela / *Vitis vinifera* / potencial hídrico foliar / riego por goteo / calidad / crecimiento