Irrigation Management on Wine Grapes in the Tropical Zone

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Abstract
The wine grape production in the tropical zone, and in particularly in the Brazilian semi-arid region, is dependent on irrigation practice due to insufficient rainfall and irregular distribution over three to four months in a year. Drip irrigation systems as well as vertical trellis system are predominant for wine grapes in this region. Some of the irrigation management guidance in practice in the field is based on previous experience and knowledge from other regions with some climate similarities, like USA (California) and Australia. As a relatively new crop in the Brazilian semi-arid region, first research results about irrigation scheduling or strategies in wine grapes are recent. Irrigation strategies as deficit irrigation, regulated deficit irrigation and partial rootzone drying have been evaluated. Therefore, research efforts in the Brazilian semi-arid region should be addressed to water consumption by scion/rootstock varieties, as well as ecophysiological behavior, berry and wine characteristics influenced by water management, according to local edaphic and climatic conditions.

INTRODUCTION
The semi-arid region of Northeastern Brazil (latitude 8°-9° S) is one of the New World wine making areas. In the 2000’s, a wine making area was consolidated in the São Francisco Valley, specifically in its Lower-Middle portion. Since then, wine making has changed gradually from the empiricism to scientific knowledge, based on understanding about local conditions, adaption of wine grapes varieties, determination of wine typicity, permanent quality improvement, obtainment of geographic indication, construction and dissemination of scientific knowledge, recognition by national and international wine expertises and by consumers, capacity building of several level workers of wine production chain, and entrepreneurship (Instituto do Vinho do Vale do São Francisco, 2011).

The wine grape production in the Brazilian semi-arid region is dependent on irrigation practice due to low rainfall (approximately 567 mm per year) and its largest distribution between November and March. The most frequently used irrigation system used in this region for wine grapes is drip irrigation. Vertical trellis system is most used for wine grapes and two harvests per year are feasible in consequence of high solar radiation availability throughout the year.

The challenge facing winemakers of São Francisco Valley is to improve grape quality in irrigated vineyards throughout an appropriate balance between vegetative and reproductive development, as an excess of shoot vigour contributes to a high canopy density leading to high water loss, fungal diseases, shading of grape clusters, which may negatively affect fruit compositions (Jackson and Lombard, 1993).

Much effort has been spent on developing deficit irrigation strategies to control vegetative vigour such as regulated deficit irrigation (RDI), where the water input is either reduced or withheld for specify phenological periods, or partial rootzone drying (PRD), where the water is only given to one side to the root system, while the remainder
is left to dry; or deficit irrigation (DI) where less than full ET$_{0}$ replacement is applied for the entire growing season in vineyards (McCarthy, 1997; Loveys et al., 2000).

Hence, herein is reported a short review about irrigation management on wine grapes in Brazilian semi-arid region, based on local research results already obtained.

**CRITERIA FOR IRRIGATION MANAGEMENT**

The practice of irrigation management consists basically of adoption of criteria to perform water application through an irrigation system, and they are based on soil, plant and climate attributes, which together compound a very complex system.

The most used soil attribute for irrigation management is the soil water content, but it does not mean that all growers and technicians (field technician, technical consultant) already used it in São Francisco Valley. There is some resistance by them to use soil water sensors, since the most simple like tensiometers, due to lack of capacity to operate them and of knowledge of how to use the information provided by sensor, i.e., basic concepts like field capacity, wilting point and soil water availability are rarely taken into consideration in irrigation management.

Plant attributes measurement like leaf water potential are relatively new in wine grape growing areas of São Francisco Valley. An incipient understanding of the suitability of leaf water potential in irrigation management by growers and technicians is already observed in this region.

In relation to climate attributes, the dissemination of automatic weather stations in recent years has become easier. The estimation of reference evapotranspiration, together with crop coefficients, are used to estimate the crop evapotranspiration, and then to manage the water application by an irrigation system. Undoubtedly, they are the most frequently used criteria to irrigation management on wine grapes in São Francisco Valley.

**DEFICIT IRRIGATION STRATEGIES**

In the past, the crop demand by irrigation water did not take in consideration that water bodies have a limit to supply this natural resource. As other water users have increased these demands by water, and having in mind that agriculture is the greatest water consumer in the world, together the possibility of climate changing, the view of how water should be delivered to agriculture and used by crops has changed.

As a great volume of water is needed to the plant development, the irrigator wants to know what the water deficit is which will cause the minimum or not economically important reduction of crop production. Consequently, the efficiency on water use can be enhanced, without significant impact on crop yield.

The practice of deficit irrigation (DI) is not easy, and before applying it growers and technicians should have a good knowledge of irrigation management on wine grapes, without any deficit. After, the understanding of advantages and disadvantages of deficit irrigation is the second step towards its adoption. The severity of water deficit and when it is applied are important factors which can influence the grape and wine quality.

Before and after the veraison, the water deficit reduces the leaf water potential, berry development, fruit expansion, and production, being more severe the deficit before veraison (Matthews and Anderson, 1989). Moderate reduction on vine water availability in the reproductive phase may alter the fruit composition in harvest time. After fruit set, water deficit influences on berry size and canopy development, and after the beginning of veraison, the anthocyanin concentration can be enhanced (Matthews and Anderson, 1988). This demonstrates that deficit irrigation adoption requires a higher level of knowledge by growers and technicians, to achieve the balance between vegetative and reproductive phases, i.e., a non excessive vegetative development, without significant crop production, and with desired grape quality to vine making. Also, they always have to pay attention to their local soil, climate and wine grape variety (scion and rootstock) behavior.

The practice of regulated deficit irrigation (RDI) is based on the restricting of water application to crop to make the plant water status lower than the well watered plant,
but with less severity of DI because of an eventual water application made throughout the growing season. Partial rootzone drying (PRD) is another deficit irrigation strategy based on the alternation of vine trunk to be irrigated, in approximately 15 days. This is performed to induce the abscisic acid production in rootzone portion drying, which is transported to the aerial part by the phloem and regulates the stomata closure process, reducing the plant water transpiration and consequently the vegetative growth.

MOSCATO CANELLI AND SYRAH RESULTS

In an experiment carried out at Embrapa Tropical Semi-Arid, Petrolina, Pernambuco State, in a deep, medium texture soil, vines cvs. Syrah and Moscato Canelli were grafted on both rootstocks IAC 572 and 1103 Paulsen, and irrigated by drippers. Deficit irrigation strategies (deficit irrigation, regulated deficit irrigation, and partial rootzone drying) were applied to vines, and plant, berry and wines characteristics were evaluated in three growing seasons (April to August 2004, August to November 2005, and June to October 2006).

Root Distribution

After the vineyard establishment period (18 months long, planting in September 2002), rootstocks root distribution were evaluated in March 2004, before the pruning of 1st vine growing season. In the vertical direction, the root length from both rootstocks reached 1 m depth, but differences were found only at 0-0.2 m soil layer, where IAC 572 presented higher values (45% from IAC 572 and 32% from 1103 Paulsen). Around 80% of roots from both rootstocks were found at 0.6 m soil depth, and 91% and 95% from 1103 Pausen and IAC 572, respectively, at 0.8 m. In the horizontal direction and inside the plant row, significant differences were observed (52% and 33% at 0-0.2 m, 13% and 22% at 0.4-0.6 m, and 8% and 21% at 0.6-0.8 m, from 1103 Paulsen and IAC 572, respectively). It seems that Paulsen 1103 have developed their roots closer to the trunk while IAC 572 have spread their roots over a greater soil volume, which indicates a better horizontal distribution inside the row for the latter rootstock (Bassoi et al., 2007).

Soil Water Dynamics

In the same soil where root distribution of two rootstocks were evaluated, the monitoring of soil water content in the 1.2 m depth soil profile under deficit irrigation strategies showed us that the soil water availability was consistently reduced in the upper 0.6 m soil layer, and no soil water content changes have occurred in the 0.8 to 1.2 m depth among the irrigation strategies (Bassoi et al., 2007; Souza et al., 2009). This soil water behavior was observed in the three growing seasons evaluated from 2004 to 2006. The presence of a fragipan in this soil makes its drainage slower at deeper depths. Pedological surveys carried out in São Francisco Valley have shown an expressive occurrence of soils with subsurface hardsetting that can restrict water distribution in the deeper portions of soil profile (Silva, 2000). This difficulty on deep soil drainage on this site together the continuous irrigation practice over the time make the deeper soil depths wet in most of the time. It is common to find vineyards in São Francisco Valley in soils with slow drainage in deeper soil layers.

Plant Water Status

As roots have reached 1 m depth just after vineyard establishment period, and soil water changes were in the upper 0.6 m depth, differences in stomatal resistance, transpiration, photosynthesis and pre-dawn leaf water content of cv. Syrah, grafted on both rootstocks already mentioned, were not significant due to irrigation strategies, at 106 days after pruning (ripening period) in the 1st growing season (Bassoi et al., 2007).

In the 2nd growing season, values of pre-dawn leaf water potential higher than -0.2 MPa, suggesting absence of water stress. The vine water status was more affected by rootstock than irrigation strategies. Both cultivars grafted on IAC 572 presented the highest values of midday leaf water potential and stem water potential, measured on non-
transpired leaves, that were bagged with both plastic sheet and aluminium foil at least 1 h before measurements. In both cultivars, the stomatal conductance (gs), transpiration (E) and leaf area index (LAI) were also more affected by rootstock than irrigation strategies. The IAC 572 rootstock showed a higher gs, E and LAI than the 1103 Paulsen. Differences in vegetative vigour of the cv. Syrah scion grafted onto IAC 572 rootstocks were related to its higher leaf specific hydraulic conductance and deeper root system as compared to the 1103 Paulsen, which increased the water-extraction capability, resulting in a better vine water status (Souza et al., 2009).

Yield

The only difference in vine quantitative measurements due to different irrigation strategies was found in the 2nd growing season in 2005, when Moscato Canelli presented lower cluster weight and yield when PRD was applied, in comparison with DI. No other effect was observed for both cultivars in the three growing seasons evaluated. However, rootstocks have influenced vine yield more than irrigation. In all growing seasons, yield from wine grapes cv. Syrah grafted on IAC 572 was higher than cv. Syrah grafted on 1103 Paulsen, while no yield differences were observed to vine cv. Moscato Canelli grafted on the same both rootstocks (Bassoi et al., 2007; Ribeiro et al., 2006, 2007).

Berry Quality

In the 1st growing season, only phenol concentration (g 100 g-1) was higher with PRD (0.27) in comparison with RDI (0.22). No differences were observed on total soluble sugar content (TSS), titratable tartaric acid content, and anthocyanin levels (Bassoi et al., 2007). In 2nd growing season, only TSS was higher in RDI (23.7° Brix) than in PRD (22.1° Brix) for cv. Moscato Canelli (Ribeiro et al., 2006).

Wine Quality

In the 3rd growing season, for all irrigation treatments (FI, RDI and PRD), wines from Syrah grafted on IAC-572 presented higher total anthocyanins than Syrah wines from 1103 P. Nevertheless, Syrah wines from Paulsen 1103 presented higher total tannins than wines from Syrah on IAC-572. Syrah wines elaborated with grapes from vines irrigated by PRD grafted on Paulsen 1103 presented higher alcohol levels and IPT, as compared with the other treatments, and wines from FI treatment on IAC 572 rootstock presented the highest total anthocyanins values. For tannins, the highest value was observed in wines from vines irrigated by FI on 1003 Paulsen rootstock (Pereira and Bassoi, 2008).

CHENIN BLANC RESULTS

In a vineyard located at Lagoa Grande, Pernambuco State, Brazil, an experiment was carried out in a drip irrigated and two years old vine cv. Chenin Blanc grafted on IAC 572, conducted in a pergola trellis system in a sandy soil. The application of irrigation water based on different crop evapotranspiration - ETc (75%, 50%, 50 and 75% mix and 37% of ETc). The deficit irrigation strategy based on 37% of ETc, which was the one already adopted by the farm, has enhanced the wine quality, by higher concentration of sugars and lower acidity in berries, and higher alcohol and pH levels, best color intensity and quality flavors, structured, body, equilibrate and higher persistence. However, grape production (3 kg per plant) was lower than other treatments, which ranged from from 5.8 to 7.1 kg per plant (Costa, 2009).

The same author also reported that in most of the plant water status evaluation the pre dawn water potential did not differ among 75%, 50%, and 50% and 75% mix ETc treatments, but stem water potential was more suitable to detect differences among them. The values of base water potential reported were similar to those observed by Souza et al. (2009), but within the range of water stress considered as null or moderate by Deloire et al. (2004).
CONCLUSIONS

In the Brazilian semi-arid region, one of the New World wine making areas, research results have already demonstrated that cropping and behavior of wine grapes are very specific to this local soil and climate conditions. Continuing research is fundamental to better understanding on how a deficit irrigation strategy can influence a specific scion / rootstock performance in a soil type and under local climate conditions. Also, minimum knowledge about plant water responses in São Francisco Valley, specifically in its Lower-Middle region, indicates specific vine performance and wine characteristics, different from other wine making areas around the world.

Literature Cited


