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Effect of post veraison regulated deficit irrigation in production and berry quality of Autumn Royal and Crimson table grape cultivars

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ABSTRACT

A field experiment was performed in two drip-irrigated seedless table grape vineyards (*Vitis vinifera* L. cv. Autumn Royal and Crimson) from 2007 to 2009 in a semiarid area of north-eastern Spain to evaluate the effect of post veraison regulated deficit irrigation (RDI) on the grape yield and quality. The same experimental layout was used in both cultivars. Two RDI treatments were compared with a full irrigation treatment in both cultivars. The full irrigation treatment (T1) was irrigated at 100% of the net irrigation requirements (NIR). The RDI treatments (T2 and T3) were irrigated as T1 except from veraison until harvest, when they received 80% and 60% of NIR, respectively. Average water saving in T3 was around 15% of the seasonal water applied in the treatment T1 while this saving in T2 ranged between 6% and 8%. Similar grape yields were obtained in the different irrigation treatments for the Autumn Royal cultivar during 2007 and 2009. However in 2008 the yield of T2 (46.0 kg vine^{-1}) was significantly higher than in T3 (34.4 kg vine^{-1}). For the Crimson cultivar, the grape yield of T3 was significantly lower than T2 in 2007 and 2008. In 2009 low grape yields were obtained in all treatments of the Crimson cultivar and no differences were observed between them. The quality parameters of the berry in both cultivars were not affected by the irrigation treatments. Berry cracking in Autumn was high in 2007 ranging from 14.7% to 21.4% and very low in 2008 and 2009 ranging from 1.5% to 4.3%. The reduction of berry cracking was attributed to the splitting of the irrigation dose in two applications per day, one at midday and the other one at night. Significant differences between irrigation treatments were observed in the CIELab color parameters of the berry skin in the Crimson cultivar. The overall results during the three study years showed that high grape yields of very good quality can be obtained with moderate regulated deficit irrigation in the post veraison phase without affecting grape quality in the Autumn and Crimson seedless cultivars in the arid conditions of the lower Ebro Valley in north-eastern Spain

1. Introduction

In 2010 the vineyard surface for table grape production in Spain covered an extension of 16,000 ha, with a total grape production of 237,000 Mg, whereas the vineyard surface for wine production was 980,000 ha with a production of 5,900,000 Mg (MAAMA, 2011). About 94% of the table grape production is located in the coastal areas of south of Spain. In the north of Spain, plantation of some commercial vineyards have been recently performed, they are achieving very high yields and with very high quality in some areas such as the lower Ebro river basin. The high productivity and quality of this crop in new irrigated areas in this region seems to be due to the use of new cultivars, favorable climatic conditions and low incidence of fungus diseases.

Many studies around the world have been performed on the effect of deficit irrigation (DI) on the response of crops. Recent reviews of literature agree to indicate that DI is a very useful tool to stabilize yields and increase water productivity in areas with water scarcity (Fereres and Soriano, 2007; Geerts and Raes, 2009; Ruiz-Sanchez et al., 2010). When irrigation water supply is limited, DI becomes a useful agronomic tool since water productivity should be the objective rather than the maximization of the yield per unit of area (Geerts and Raes, 2009). The term regulated deficit irrigation (RDI) is used when the DI is applied in the drought tolerant phenological stages of the crop that often are the early vegetative stages and the late maturation stages. For the last three decades, RDI has been successfully used in orchards of different fruit species such as peaches (*Prunus persica*) (Chalmers et al., 1981; Boland et al., 2000a,b; Girona et al., 2003; Lopez et al.,

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2008), apricot (*Prunus armeniaca*) (Ruiz-Sanchez et al., 2000; Perez-Sarmiento et al., 2010), plums (*Prunus domestica*) (Intrigliolo and Castel, 2005), cherries (*Prunus avium*) (Marsal et al., 2010), pears (*Pyrus communis*) (Marsal et al., 2002), almonds (*Prunus amigdalus*) (Romero et al., 2004; Goldhamer et al., 2006; Stewart et al., 2011), olive (*Olea europaea*) (Iniesta et al., 2009) and citrus (*Citrus sinensis*) (Garcia-Tejero et al., 2010; Ballester et al., 2013).

In wine vineyards, full irrigation is not recommended since it increases the berry size and this produces a decrease of the skin pulp ratio which is detrimental for the wine quality (Ruiz-Sanchez et al., 2010). RDI techniques have been widely used in wine grapes (Acevedo-Opazo et al., 2010; Santesteban et al., 2011; Ortega-Farias et al., 2012). The general practice of RDI in vineyards consists in a reduction of irrigation in the pre veraison or post veraison phases in order to maintain yield and improve the quality of the must (Wade et al., 2004; Ferreyra et al., 2004; Chalmers et al., 2004). The veraison represents the transition between the berry growth to the berry ripening and it is characterized by a change in the color of the skin of the berries. Usually improvement of must quality is associated with increases of the pulp skin ratio, intensity of the color, anthocyanins and total soluble solids contents (Williams and Mathews, 1990).

In table grape vineyards, full irrigation is usually recommended since maximum production and size of the berries is desired (Blanco et al., 2010). In table grape cultivars the berry size, firmness, sweetness and color are important variables as shown by Williams et al. (2010). These berry quality parameters differ from the wine quality parameters and therefore irrigation practices to optimize berry quality can be quite different. Deficit irrigation studies in table grape are very limited. However deficit irrigation can be of interest to improve some of the quality parameters of the berries such as color, total dissolved solids and aromas (El-Ansari et al., 2005).

El-Ansari et al. (2005) compared the effects of moderate (irrigation 2 days after soil water potential reached −15 kPa) and severe post veraison RDI (irrigation 4 days after soil water potential reached −15 kPa) with a control treatment (irrigation when soil water potential reached −15 kPa) on the quality of table grapes cv. 'Muscat of Alexandria'. Their results showed that the moderate RDI had no effect on berry weight or juice quality at harvest. However the severe RDI decreased berry size, firmness and acidity and increased total soluble solids of the berries. In an experiment with the table grape cultivar 'Danlas' under different irrigation regimes, Ezzahouani and Williams (2007) found that the highest yield and berry weights were obtained in the most irrigated treatment and no significant differences were observed in berry acidity between treatments.

The cultivation of seedless table grape cultivars have increased considerably in the last decades since consumers of many countries appreciate very much the lack of seeds in the berries and the firmness and sweetness of these new varieties. Spain is the first European producer of seedless table grapes. Autumn Royal presents a high commercial value, with a big berry, purple-black to black in color that matures around mid-September in the lower Ebro river valley. This cultivar is susceptible to berry cracking, which is a serious problem because it increases the labor required since the clusters need to be cleaned during the maturation phase until the harvest. At harvest, the cracked berries must also be manually removed to avoid cluster rot. Several authors have studied this problem in different table grape varieties, although due to its complexity a definitive solution to solve this problem has not been reached (Considine and Kriedemanm, 1972; Matthews et al., 1987). Another problem in this cultivar is the weak attachment of the berries to the rachis, so clusters must be very carefully handled in the harvest in order to avoid the berry loosening (Dokoozlian et al., 2000).

Crimson is also a late-season red seedless table grape cultivar extensively cultivated in California and Europe. This variety has excellent eating characteristics; berry texture is firm and crisp, and its flavor is sweet and excellent. One of the main problems of this cultivar is the lack of color at harvest. It is critical that clusters be exposed to adequate sunlight during ripening for maximum fruit coloration. The lack of incident radiation in the clusters and the excessive crop loads delay maturity and decrease coloration. One extended practice to avoid this problem is the shoot thinning and the removal of basal leaves surrounding the clusters in order to increase the incidence of light in the clusters in the overhead trellis systems.

The aim of the study is to ascertain the effect of two levels of RDI applied from veraison to harvest on the yield and berry quality of table grapes Autumn Royal and Crimson cultivars. The hypothesis is that changes in irrigation management and the application of RDI in the post veraison phase can maintain yield and improve berry quality and especially decrease berry cracking in the Autumn cultivar and improve the skin color redness of the Crimson cultivar.

2. Material and methods

2.1. Experiment description

The same field experiment was conducted in the Autumn Royal and Crimson plots of a commercial vineyard located in the Santa Barbara commercial orchard, in the county of Caspe (Zaragoza, Spain) (41.16° N, 0.01° W) during 2007, 2008 and 2009. Both table grape cultivars were grafted on Richter 110 rootstock (*V. berlandieri* × *V. rupestris*) planted at a distance of 2.5 m between vines and 3.5 m between rows. Row direction was northwest to southwest. The vines were planted in 2002 in a sandy loam soil. The vine rows were planted in an elevated soil levee around 0.3 m high and 1 m wide. The soil of the plots has been developed upon colluvial deposits of higher river terraces. It is deep, properly drained, with quite coarse textures, a considerable percentage of stones, with a high calcium carbonate content (>40%), with no sodicity (SAR = 2.4) and slightly saline (Electrical conductivity, ECe < 4 dS m^{-1}) (Soil Survey Division Staff, 1993). The soil is classified as a Xeric calcigypsic, coarse loamy, mixed (gypsic), thermic (Soil Survey Staff, 1999, 2006). The average values of soil field capacity and permanent wilting point in the 0–30 cm soil layer were 26% and 10% on a gravimetric basis. The average soil bulk density was 1600 kg m^{-3}. The vines were trained to an overhead Spanish horizontal trellis system, with vertical metallic stakes which hold a wire grid located at 2.2 m, where the vine canopy develops. The trellis system is covered with a white screen net made of high-density polyethylene (Criado and Lopez, Almería, Spain) at a height of 2.5 to 3.0 m above the ground level for crop protection. This net was translucent with individual openings of 12 mm^2 (2.2 mm × 5.4 mm). The reduction of solar radiation of this net measured in the field was 15% (Moratiel and Martínez-Cob, 2012). The vineyard was managed according to the usual cultural practice in the farm. Cluster pruning was performed just after fruit set in order to obtain a uniform bunch load per vine. The vineyard was irrigated with a drip irrigation system with one lateral in each row of vines with integrated self compensating emitters of a discharge of 2.2 L h^{-1}, spaced 0.5 m. During the 2007 irrigation season irrigations were applied daily at night. In 2008 and 2009 the irrigation timing was changed from a single night application to two irrigation events, one at noon and a second one after midnight. Each vine had four main branches and every winter the vines were pruned to maintain this structure. An additional summer pruning of the shoots in a strip 0.5 m wide between vine rows was performed around veraison to improve light penetration in the