Sustainability of the Legal Endowments of Water in Almond Trees and a New Generation of High Quality Hydrosustainable Almonds – a review

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Abstract

The great consumption of water and its scarcity in many areas of the world leads „irremediably" to accept that Spanish agriculture, like other Mediterranean agricultures, must adapt to the lack of this natural resource. Deficit irrigation (DI) strategies are routine practices used worldwide in order to increase net farm income by growing the crops effectiveness to use water. The importance of using this type of strategies is the fact that farmers have the opportunity not just to reduce the water consumption but also to obtain hydro sustainable products. Those are "theoretically" characterized by a high accumulation of secondary carbon metabolites in plant and a great accumulation of bioactive compounds in fruit, according to other studies already done in pistachio or table olives. As almond is the major nut crop in Mediterranean area different DI strategies are presented within this review together with their effect on the final product quality. Thus, the aim of the current review paper is to find all the necessary information about which DI strategies are the recommended to be applied in the almond crop in order to obtain high-quality fruits environmentally friendly. In addition, methods used to determine de quality and steps necessary to certify and protect this type of products are also presented.

Keywords: bioactive compounds, nut crops, deficit irrigation (RDI, SDI, PRD), PUFAs, *Prunus dulcis*

Introduction

Water scarcity means the deficiency of fresh water resources to face water demand. There are 37 countries worldwide which are facing extremely high levels of water stress; this means that more than 80 % of the available water for agriculture and other needs is decreasing annually (World Resource Institute, 2017). This subject was considered the biggest global risk because affects every continent but mostly in terms of possible impact over next decade. The nowadays population is around 7,6 billion, so the food claim is in a continuous increase, which means that water use in irrigation will growth around 30 % if using current values of agricultural water use efficiency (Du et al., 2015). As explained above, water availability and scarcity are worldwide problems and Mediterranean agriculture, as models of arid and semi-arid farming areas, must optimize this natural resource to get sustainable. Thus, the agriculture challenge must be the improvement of water productivity supplying high quality, secure and sustainable food products. Spain is a country with high levels of water stress and especially in the southeast region, which is characterized by low rainfall and high evaporative demand during the almond growing season (Egea et al., 2013). Besides, almond is the major nut crop in Mediterranean area and its production and profitability depend on the irrigation supply (Egea et al., 2013). In order to face this worrying situation, many researchers suggest using deficit irrigation strategies (DI), due to their positive effects on water productivity. Many DI strategies were developed for almond crops in order to reduce water consumption and some of them will be described in this review. The use of DI strategies produces a new generation of products called hydro sustainable food. Thus, the aim of this paper is to present not just deficit irrigation strategies on almond crop but also their effect on fruit yield and quality. Finally, but not least important within this review some future perspectives on hydro sustainable almonds quality determination and product protection by a brand (*hydroSOS*) will be included.

Deficit irrigation concept

Crops are using water within the evapotranspiration (ET) and other losses from the allocation of water to the land. Due to the salt presence in all irrigation waters, losses are inevitable and necessary to maintain the salt balance for an appropriate crop production. Even though, those losses can be minimized by using adequate management and efficiency of irrigation practices. Previously, research emphasized the using of enough water for a maximum crop transpiration; in this way assuring full ET during the whole growing cycle and an increment in biomass production (Fereres et al., 2006). Over time and having as model rain-fed areas with water resources below to the maximum ET needs, researchers proved that is possible to apply water below the ET requirements (deficit irrigation) with few or any impact on the final product quality (Du et al., 2015). According to Fereres et al., (2006), DI is more effective in tree than in field crops, due to their tall and rough canopy which is well connected to the atmosphere, and a reduction in stomatal conductance will increase proportionally to a higher degree in the trees canopies. Many researchers observed yield benefits and high-quality products in fruit tree if water stress at certain growth period was applied.

Responses in plant physiology

For an appropriate DI, strategy development is essential to understand the plant physiology. The plant leaf surface contains pores called stomata through which exchange H_2O, O_2, CO_2 and other elements with the environment (Figure 1).

As can be seen in Figure 2 if water stress is applied causes stomatal closure and reduces the amount of transpiration.

Also, as can be seen in the Figure 3, in stressed conditions caused by DI the stomatal size decreased but the density was increased, which means that the plant has been adapted to drought (Du et al., 2015). When a plant is completely irrigated, the leaf stomata are totally opened and ready for the CO_2 intake, at the same time water and oxygen are released. Therefore, the plant should increase the drought resistance by reducing the stomatal opening when water stress is applied. Thus, the ideal plant should be able to manage the water loss by noticing the intensity of drought and activate defense mechanism such as stomatal conductance adjustment. According to research on this subject, this process is carried out through some chemical growth regulators which react as signals when water stress is detected. This type of chemicals are not just the plant minerals but also cytokinins, abscisic acid (ABA) and 1-aminocyclopropane-1-carboxylic acid (ACC). Before water deficit is detected in the shoots, the roots signals must decrease water losses through stomata, and if the water deficit continues, the plant should keep defending itself by diminishing gradually the shoot turgor. This second defense process occurs by producing enormous quantities of ABA in the inferior leaves but also in the old ones and then transferring it not only to the buds but also to the young leaves. In conclusion, according to this theory water losses are substantially reduced so the plant is able to survive under drought condition due to their ability to regulate water potential (Zhang et al., 1989). Nevertheless, is highly recommended not to apply water deficit during the plant growing because, for cell development, activity and production is necessary

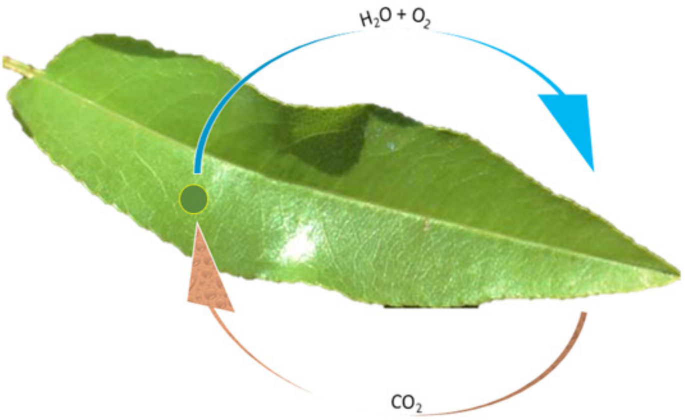

Fig. 1. Plant exchange elements with environment through leaf stomata

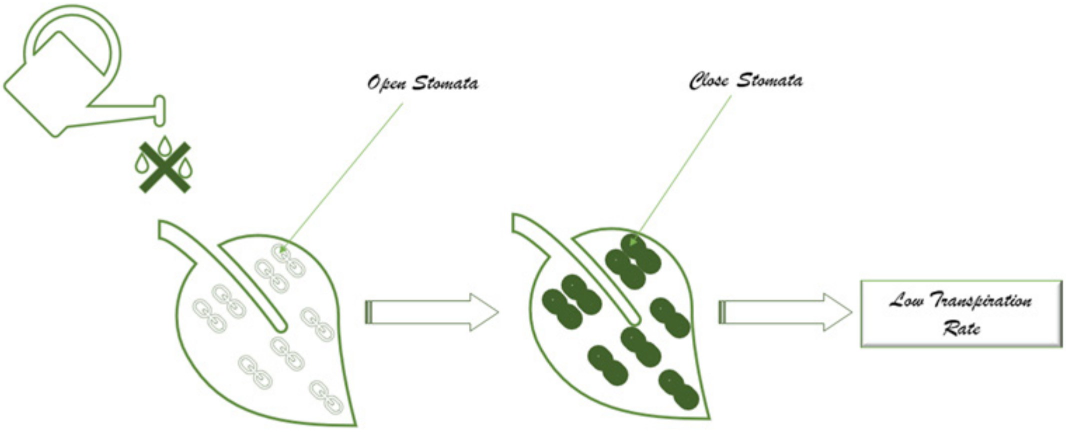

Figure 2. Effects on leaf stomata when a deficit irrigation is applied

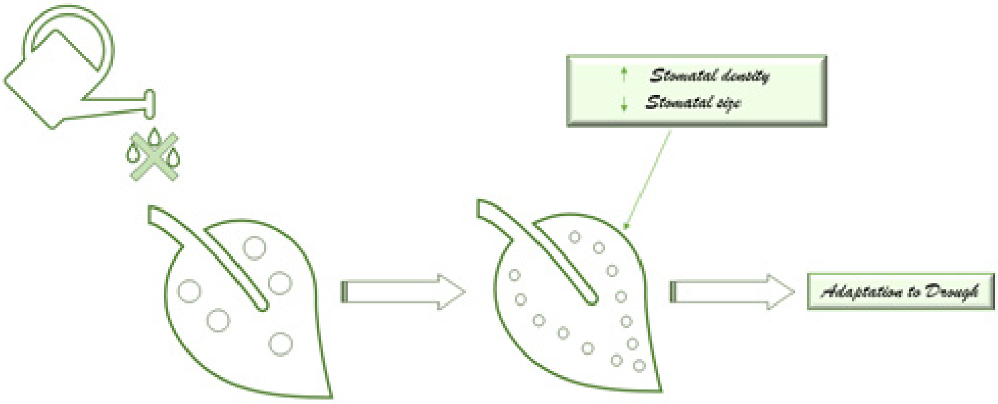

Figure 3. Effects on leaf stomata when

a minimum water status in order to obtain yield and high-quality product (Du et al., 2015).

Deficit Irrigation Strategies

There are plenty of deficit irrigation practices, but the main ones described in this review are three: Regulated Deficit Irrigation (RDI), Sustained Deficit Irrigation (SDI) and Partial Root-zone Drying (PRD).

The Regulated Deficit Irrigation (RDI) approach was developed in the 1970s and is characterized by applying less amount of water in certain periods of the growing cycle that are less sensitive to the water stress. The first step is to establish the full crop water requirements (ET) and second is to apply a percentage of water depending on the phenological state to calculate the final irrigation quantity. This practice theory is that chemical signals from the drying roots can control the stomatal behavior and leaf growth by reaching the shoots, so it allows plants to grow and survive under water stress. Thus, within this technique the irrigation water amount is reduced, therefore the water productivity is increased. In order to reduce cost on pruning, RDI was also applied to control the excessive vegetative growth. So, besides increasing the water productivity, this strategy, also raise the profitability for growers (Du et al., 2015).

Sustained Deficit Irrigation (SDI) consists of applying a smaller amount of water at each irrigation during whole fruit season, rather than hold back water during a period of time as in other practices. In other words, using this practice a water stress is created by not refilling completely the root zone while irrigation (Goldhamer et al., 2006).

Partial Root-zone Drying (PRD) strategies, as the name explains, are characterized by one part of the root-zone getting irrigated while the other one is drying until a particular soil water content is reached, at this moment irrigation system is moved to the dry root-zone. The premise of this practice is that while the roots of the irrigated side are absorbing enough water to sustain the plant water condition, the other (dry) side of the root is responsible for ABA hormone synthesis, necessary to reduce the leaf growth and stomatal conductance (Galindo et al., 2017). However, there is not yet known perfect irrigation timing for each root-zone.

Deficit irrigation strategies applied to almond trees

Almond trees (*Prunus dulcis)* constitute a major tree nut crop in the Mediterranean region. From a profitability point of view, the kernel dry weight and fruit load are the key factors. On the other side, fruit composition as fat, sugar, protein, fiber, etc., are determinants on fruit quality. For both production and profitability irrigation plays an important role. As Mediterranean basin has an extremely dry soil due to the scarce rainfall and high evaporative demand during almond growing season the growers must adopt DI strategies in order to obtain profitability, high-quality products and last but not least environmentally friendly (Egea et al., 2013).

Almond growing cycle can be shared in 4 stages and the impact of water stress under the almond crop is conditionate by the time of the year when it is applied, as can be seen in Figure 4. Stage I correspond to flowering and growth in the size of fruit (March-April), Stage II to growth in the size of the embryo (May), Stage III to increment in weight of seed or kernel filling (June-August) and Stage IV which correspond to Postharvest (Doll, 2014). Doll (2014) explained in his study about almond production in drought conditions that the application of water stress at intermediate or severe level during any point of growing season is not recommended because will reduce the vegetative growing what leads to low future outputs. During Stage I, if severe water stress occurs, smaller fruits and kernel size will be observed due to the reduced cell division and expansion. Applying water stress during Stage II will decrease the carbohydrates so the kernel size. If water stress is applied in Stage III of fruit development kernel carbohydrates production will decrease due to an early accelerated hull split, what leads to textured or shriveled almond kernels but also to a diminution of kernel dry weight. However, using water stress at the final half of Stage III it shows very low impact on kernel yield and quality. Finally, water stress in Stage IV (postharvest) must be soft because at severe level can reduce yields until 74 % in the following year (the kernel size and quality in current season is noticeable also but not so severe as in the next year's crop) due to the stress impact on the floral bud evolution.

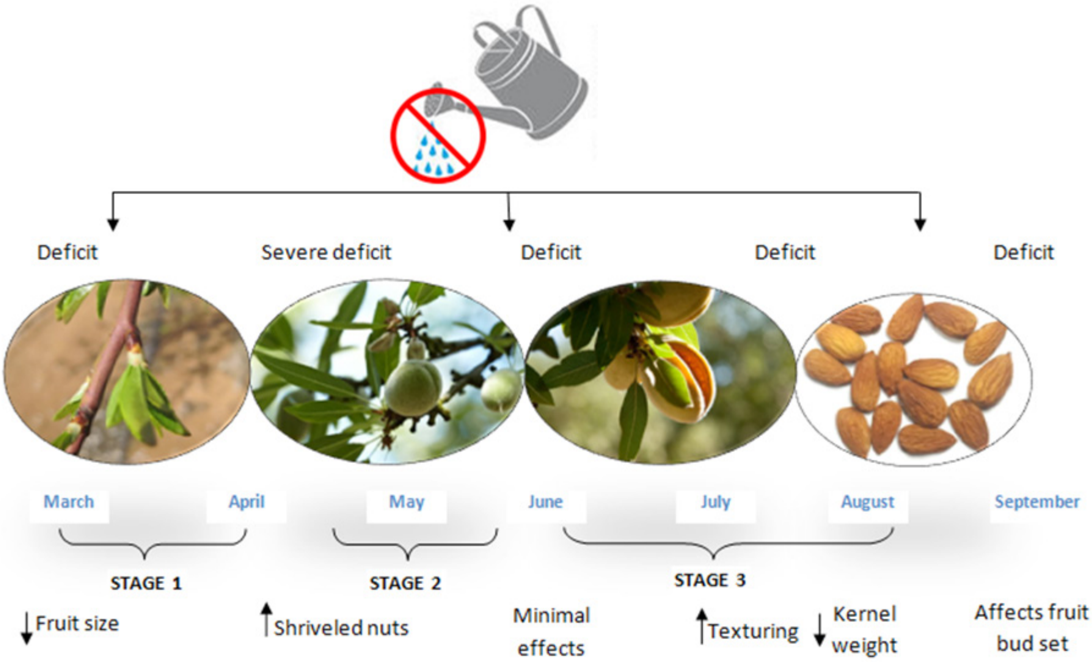

Figure 4. Almond growing cycle and the best moment to apply water stress

Authors such as Goldhamer et al. (2000) investigate effects of pre and post-harvest water deficit in almonds. Overall is known that flowering, fruit set and the initial phase of fruit growth are very sensitive to water stress. Besides, farmers recommend cutoff irrigation before harvest to prepare the orchard soil. Dry soil is needed not just only for the fruit left on the ground for drying but also for the tree hardness before shaking in order to avoid bark harm. Thus, he focused on applying DI in post and pre-harvest period and concluded that post-harvest deficit irrigation can be more harmful to the yield of the following season than the equivalent amount applied in pre-harvest. Using longer water stress before harvest hull rot was eliminated, but on the other hand, full hull split and kernel weight were reduced. So, growers should bias irrigation towards the postharvest period in order to obtain a sustained and sustainable productivity. The same author in another study found for all irrigation treatments studied that the best yields were obtained when water was applied at a uniform rate during all season. Nevertheless, even all treatments had a negative effect on kernel weight with respect to the control (~970 mm), the most severe treatment (~600 mm) presented an increment of fruiting density and a decrease in the tree canopy size. Thus, changes in water management must be applied in order to reduce the water consumption, pruning and higher fruit yields (Goldhamer et al., 2006). Oher authors such as Egea et al. (2009) have compared the almond kernel quality using RDI and PRD (70 %, 50 % and 30 % of full water requirements) as irrigation treatments. They concluded that deficit irrigation does not affect the global fruit growth pattern, neither the chemical composition (lipid, protein, sugar and organic acids) if compared to full irrigation control. On the other side, negative impact on the final kernel dry weight was observed for the severe treatments. Regarding DI strategies, Egea et al. (2009) summed up that there were no clear advantages by using PRD instead of RDI in almond fruit development and quality. The same authors in another study compared RDI (40 % ET during kernel filling) and SDI (mild to moderate = 75-60 % and moderate to severe = 60-30 % during the whole growing season, for a total of six growing seasons) with full irrigation as a control (FI = 100 % ET). They found that moderate to severe SDI seems to be a good option for the arid areas with high levels of water scarcity, while mild to moderate SDI and RDI are good options for areas less affected by water scarcity. RDI in particular, showed the ability to prevent the vegetative growth, enhancing fruiting density and production efficiency Egea et al. (2013).

Zhu et al. (2015) have studied fatty acids and tocopherol concentration on almonds under deficit irrigation strategies RDI and SDI moderate (85 %, severe 70 % and extreme deficiency levels 55 % of potential crop evapotranspiration) but also the control (100 % ET) and over irrigation (120 % ET). They could not find a correlation between years regarding lipid quantity and may be attributed to the climate and the fact that almond tree is a perennial tree crop. However, regarding DI treatments, moderate deficit irrigation both RDI and SDI strategies had no negative impact on kernel lipid content but did have when severe and extreme water deficit has been applied. For the almond trees irrigated with an excess of water did not produce higher levels of lipid or tocopherols, neither an increase in kernel size, unlike both nutrient and size were not increased. Saturated and unsaturated fatty acids ranged under the treatments, the oleic/linoleic ratio rise under moderate water stress diminishing with severe water stress, and tocopherols concentration was firm under water stress treatments. The authors concluded that is possible to improve water productivity without significant losses on almond quality.

Authors as Carrasco-Del Amor A.M. et al. (2015) in studies about phytoprostanes (PhytoP) in almonds under the rain-fed condition, showed lower individual and total PhytoP concentration compared to those under irrigation. However, there were detected 16 series of F1 PhytoP which was not found in irrigated almonds. Same authors observed an increment of PhytoP within the regulated deficit irrigation in olive crop. For this reason, future studies in DI strategies for a greater accumulation on PhytoP are recommended. The PhytoP are bioactive compounds formed from α–linolenic acid (ALA) oxidation by a non-enzymatic pathway which is stimulated by the formation of reactive oxygen species (ROS). In other words, the PhytoP are precious compounds which can protect plants from oxidative damage by cooperate in its defense and detoxification. In addition, PhytoP own anti-inflammatory and apoptosis-inducing activities, regulating immune functions, thus they are considered nutraceuticals in humans Medina et al., (2017).

As can be seen, research in this field is still needed to reach to optimize, this essential resource, the water for almond irrigation maintaining the yield and quality in the final product. In addition, must emphasize in producing almonds with higher levels of bioactive compounds such as PhitoP, PUFAs, polyphenols, etc., by using knowledge already provided by these studies, about water stress and its positive effects in the final fruit.

Hydrosostainability concept

The hydro sustainability concept has been already used by other researchers for different crops as pomegranates, table olives and pistachios (Noguera et al., 2017). The initial working hypothesis is that with the use of „soft or moderate" water deficit levels, it is possible to achieve minimum losses in yield obtaining „high quality" products adapted to the needs and demands of nowadays consumers. This working hypothesis has been demonstrated in various crops, including pomegranates (Galindo *et al*., 2014), table olives (Cano-Lamadrid et al., 2016) and pistachios (Carbonell-Barrachina et al., 2015). In the case of table olives, Manzanilla variety, and hydroSOS pistachios, were observed a higher content of polyunsaturated fatty acids (especially linoleic - C18:2), a greater intensity of key sensorial attributes and greater consumer acceptance by Spanish (olives) and European (pistachios) consumers. However, the results obtained for pomegranates and hydroSOS pomegranate juice are inconclusive and contradictory in some cases, obtaining positive results from RDI (Galindo et al., 2016) and negative results in others (Mena et al. 2013).

As explained above previous studies in almond trees have shown that RDI can increase „water productivity" with minimal impact on the quality and yield of the final product (Egea et al., 2013). Similarly, Zhu et al. (2015), demonstrated that almond trees can grow under water stress without affecting the nutritional quality of fruits, including fatty acid and tocopherol profiles.

The existence of a brand to distinguish this type of products was proposed by the consumer in a focus group research on this topic (Noguera et al., 2017). Consumers mentioned that´´ there is a need to stand out in the crow´´ and the best way to afford information about heathy and environmentally friendly products is to create an own identity and to shear, it not only through food packaging but also through mass media. Within this study, researchers demonstrated that undoubtedly, the

European consumer is increasingly concerned about a healthy diet and lifestyle respectful with the environment. This fact has recently been demonstrated in the above-mentioned paper by Noguera et al. (2017), where Spanish consumers were willing to pay approximately 1 euro more per kilogram of hydroSOS pistachio (Noguera et al., 2017) if the product is properly identified. Thus, this study concluded that presenting these findings to the farmers is easier to convince them to adopt the DI strategies and to implement all the necessary systems (sensors, irrigation heads, etc.) necessary for a good performance. Besides, if a brand would be created and accepted by authorities an added value for the product will be obtained, so would increase the farmer interest for a sustainable agriculture, and simultaneously its profit.

Summary and future perspectives

Evaluating all the information generated on DI strategies in almond crops it can conclude that almond tree is a drought tolerant plant but increases yields when irrigation is applied. Moreover, all DI strategies applied in almond crop in a soft or moderate level do not affect either the quality of the final fruit or yield. Both seem to be affected when high levels of water stress are applied. So, further research is recommended to establish standards which can be followed by farmers to produce hydro sustainable products.

Applying to almonds, the finding about the consumer willingness to pay for hydroSOS pistachio a calculation has been done in Table 1. As indicated in the MAGRAMA Statistical Yearbook (MAPAMA, 2016), the price of shelled almond in the field is 4.85 euros/kg, the increase of up to 1 euro that consumers would be willing to pay would mean a 20 % possible increment for hidroSOS almonds comparing with the conventional ones, which means a huge benefit for the sector, and especially for the farmers Table 1. However further investigations are necessary in order to check the consumer willingness to pay for almonds produced under controlled water stress conditions. In addition, if the hidroSOS brand will be created to protect hydro sustainable products, an hidroSOS index must be developed to certify that all products labeled with this stamp meet the standards required to be a hydro sustainable product.

Therefore, and considering the previous knowledge already available on this topic, it is necessary to evaluate more farming scenarios to clearly establish the intensity and the ideal moment to apply water stress to can obtain high quality hydro sustainable almonds adapted to the European market. Consequently, an experiment about the effects of DI strategies in hydroSOS almonds to determine functional, sensory quality and consumer acceptance will be of high importance. For these reasons and following researches already done in different hydro sustainable products an experimental design is been proposed for the hydro sustainable almonds:

Key parameters needed to study hydrosostainability

Experimental design

Many authors (Cano-Lamadrid et al., 2016; Carbonell-Barrachina et al., 2015; Egea et al. 2013) working on this topic investigate at least two consecutive growing seasons for relevant responses. First, they start by creating an experimental design in orchard applying different DI strategies together with the control which is full irrigation and assures the maximum crop

Table 1. The possible increase for hydroSOS almonds vs conventional if the consumer is willing to pay 1€ more/kg hydroSOS almond as found in hydroSOS Pistachio studies (Noguera *et* al., 2017).

ASP*	Price CA*	Price AhSOS*	CA Value*	AhSOS Value*	Possible Increase*
kg /year	(€/kg)	(€/kg)	million € /year	million € /year	million € /year
190000000	4,85	5,85	921500000	1111500000	190000000
					20,62 %

ASP* = Almond Spanish Production (MAGRAMA, 2014)
Price CA* = Price received by the farmers for Conventional Shelled Almonds
Price AhSOS*= Price received by the farmers for the HidroSOS Shelled Almonds

water requirements (100 % ET). Some of them comparing RDI with PRD and SDI, others DI and rootstock, irrigated trees and rain-fed trees and so on. The idea is to establish the perfect deficit irrigation strategy maintaining the yield and improving the fruit quality. Usually, these treatments are scheduled depending on trunk diameter fluctuations to get different levels of water stress such as (soft, moderated and sever). Besides, the climate condition including temperature and annual rainfall is well checked, together with the corresponding value of reference crop ET by using FAO-Penman-Monteith equation (Egea et al. 2013). Some examples of irrigation treatments studied in almond crops can be seen in Table 2. For monitorization of soil and tree water status authors have been used a frequency domain reflectometry probe and a pressure chamber for predawn leaf water potential determination. Besides, the vegetative growth was monitored by measuring trunk circumference with a tape measure.

Physicochemical analyses

In order to see how the DI affects yield, nutritional and functional value of this type of products, different quality parameters have been studied. Many measurements and physicochemical analysis are recommended in this way and some of them are presented below.

For the morphological properties, the authors recommend the following analysis: weight, instrumental color, texture and water activity by using a scale, caliber, colorimeter, texture analyzer and a_w meter (Cano-Lamadrid et al., 2016; Carbonell-Barrachina et al., 2015). For the texture measurement in studies about other nuts authors recommended using cutting test using a knife plate which is an empirical indicator of the force that is needed to cut the almond (Carbonell-Barrachina et al., 2015).

On the other hand, authors working on this topic consider the volatile compounds a parameter to be analyzed in order to see if there are differences or not between DI treatments. This parameter was determined through Solid Phase Micro Extraction (HS-SPME) method using a type of fiber with high ability to capture aromatics. Those compounds were identified via gas chromatography coupled with mass spectrometer detector (GC-MS). The identification was done by using retention indices, retention time and mass spectra and the results are will be expressed in percentage of the area of each aromatic (Cano-Lamadrid et al., 2016; Carbonell-Barrachina et al., 2015).

As described by Carbonell-Barrachina et al. (2015), the oil can be extracted with *n*-hexane under sonication bath, centrifugated and recovered by *n*-hexane evaporation. Fatty acids are

Table 2. Examples of irrigation treatments studied in almond crops.

Deficit Irrigation	**Irrigation Water Applied**		
	mm		**%**
FI	600	456	100
RDI	332	251	85
RDI			70
RDI			55
PRD	358		
PRD	256		
PRD	168		
SDI		341	85
SDI		266	70
SDI			55
Over Irrigated			120
References	Egea *et* al. (2009)	Egea *et* al. (2013)	Zhu *et* al. (2015)

a valuable parameter which can make the difference between control and deficit irrigation products as found in current studies on olive and pistachio (Cano-Lamadrid et al., 2016; Carbonell-Barrachina et al., 2015). Authors described the fatty acids determination by using the obtained oil saponified with dichloromethane and methanolic NaOH solution, boiled for 10 minutes at 90 ºC. After, boron trifluoride was added and boiled for 10 more minutes. Hexane was added to the mixture in order to recuperate the fatty acids and the obtained fatty acids methyl esters are ready for GC-MS identification and quantification.

Also, minerals content was analyzed by Carbonell-Barrachina et al. (2015) in the study of hydro sustainable pistachio. The method used in this case for mineral content determination was the digestion of sample with nitric acid using a digestion block and atomic absorption-emission spectrometer for micro and microelements determination (Carbonell-Barrachina et al., 2015).

Antioxidant capacity and total phenolic compounds also can be a good parameter in hydro sustainable products determination. The method of determination was described by Cano-Lamadrid et al. (2017) in a study about pomegranate phenolic compounds and was made through an extraction with methanol/water solution under sonication and evaluate by using DPPH$^{\cdot}$, ABTS$^{\cdot+}$ and FRAP methods.

The method of sugar and organic acids determination was well described by Dafny-Yalin et. al., (2010). Thus, these elements can be extracted with distilled water, homogenized by Polytron, filtered with 0.45 μm Millipore membrane filter and injected into HPLC equipment. The sugars are detected by a refractive index detector while the organic acids by using their absorbance at 210 nm with UV detector.

Once the treatments that produce the fruits with greater functionality and quality are identified, those products will be used to develop the next steps essentially for a brand certification methodology.

Sensory analysis was proved to be important parameters to distinguish the hydro sustainable products from the conventional one (Cano-Lamadrid et al., 2016; Carbonell-Barrachina et al., 2015; Noguera et al., 2017). In order to prove this, the author used descriptive and affective sensory tests. To assure that the sensory quality of hydroSOS products is adequate a specific lexicon was developed by using descriptive sensory analysis. Authors such as Vazquez-Araujo et al., (2012), described the methods necessary to develop a lexicon for *turron* product. Besides, affective tests with European Union consumers were done in which they were also asked about their willingness to pay. Carbonell-Barrachina et al., 2015 affirm that to ensure the acceptance of hydroSOS products and their correct adaptation to the target markets (European Union, EU), affective studies are recommended to be conducted in different sides of EU. For this purpose, can be used 9-point hedonic to measure the satisfaction degree and Just About Right scales (JAR) is recommended to evaluate the intensities of sensory attributes. Beside this also can be used Check All that Apply questionnaires (CATA), willingness to pay, socioeconomic, consumer habits and purchase intent questions (Cano-Lamadrid et al., 2016; Carbonell-Barrachina et al., 2015; Noguera et al., 2017).

Expected results after the implementation of hydrosostainable irrigation strategies

Authors such as Romero et al*.* (2005) and Memmi et al*.* (2016) stated in their studies with nuts (almond and pistachio, respectively), that the water savings obtained in RDI treatments were 45% with respect to the control. In the RDI strategy where 20% water was used during the kernel-filling phase and 50% post-harvest, each kilogram of almonds cost about 0.03 euros less than the control (Romero et al., 2005). These already published data show the clear economic benefits of the use of these irrigation strategies may have for the agricultural sector, especially for the semi-arid areas such, as Vega del Segura area (Romero et al., 2005, Memmi et al., 2016). In addition to its normal consumption, almond is also used as the main ingredient in the production of *turrón*. For this, it is essential to obtain the maximum yield of the almond (Bouet et al., 2017).

Usually, plants submitted to a water stress in a soft or moderate level obtained positive results in lipid content, polyunsaturated fatty acids and sensorial acceptance by consumers (Cano-Lamadrid et al., 2016; Carbonell-Barrachina et al., 2015; Noguera et al., 2017). Some results are represented in Table 3. Besides, RDI treatments in almonds and pistachio did not affect significantly

Table 3. Parameters positive affected by RDI strategies in almonds, pistachio, and olives.

Parameters	Treatments	Almonds	Pistachios	Olives
Units		Kg/tree		t/ha
Yield	Control	20,1	59,4	6,6
	RDI	17	48	5
Units			%	
Lipid Content	Control	49,0	40,6	27,8
	RDI	52,0	42,1	34,1
Oleic acid	Control	62,0	52,0	69,3
	RDI	62,0	50,0	67,1
Linoleic acid	Control	27,0	31,2	4,9
	RDI	26,0	34,0	7,4
MUFA*	Control	64,0	54,0	72,6
	RDI	64,0	52,0	69,3
PUFA#	Control	26,1	31,2	4,9
	RDI	26,0	34,0	7,4
References		Egea *et al*, 2013	Carbonell-Barrachina *et al.*, 2015	Cano-Lamadrid *et al.*, 2016
		Zhu *et al*, 2015		
*Monounsaturated fatty acids *Polyunsaturated fatty acids				

the yield during two seasons of study neither the size and kernel weights. Lipid content was stable under moderate stress in almonds and augmented in pistachio but decreased when stressed were under severe levels (Carbonell-Barrachina et al., 2015; Zhu et al, 2015). Neither fatty acids content nor tocopherols were affected by water stress in almonds while in pistachio and table olives the linoleic acid was affected by the irrigation treatments resulting in a higher content

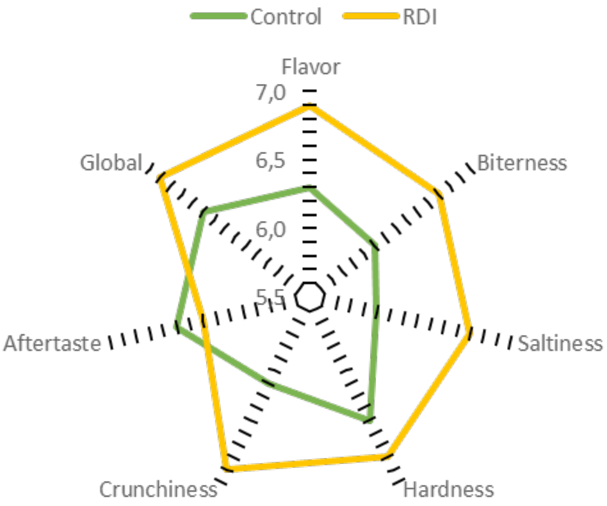

Figure 5. Affective sensory profile of ´´Manzanilla´´ table olives as affected by water stress (9-points hedonic scale) (Cano-Lamadrid et al., 2016).

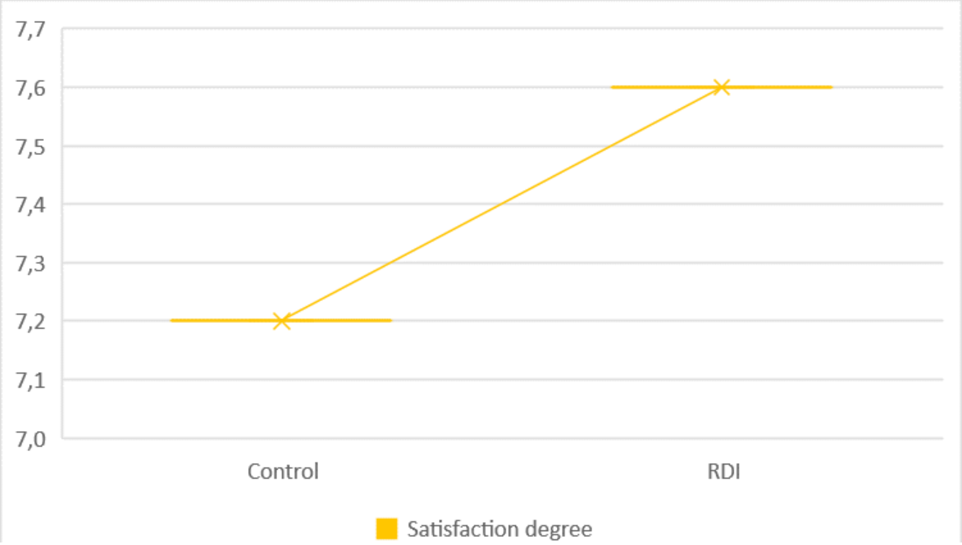

Figure 6. Satisfaction degree of pistachios as affected by irrigation treatments (9-points hedonic scale) (Carbonell-Barrachina *et al.*, 2015).

in water stress conditions (Cano-Lamadrid et al., 2016; Zhu et al, 2015; Carbonell-Barrachina et al., 2015). Cano-Lamadrid et al., (2016) showed in their study about water stressed applied in table olives trees in a moderate level will decrease the monounsaturated fatty acids and increase of polyunsaturated fatty acids. This last mentioned are essential for human health because they cannot be synthesized by our body.

In sensory studies about pistachio and olives under deficit irrigation strategies was observed a higher acceptance by consumers regarding fruits obtained with moderate levels of water stress. The consumers found a higher flavor of green table olives (Figure 5) or pistachio (Figure 6) and crunchy texture (Cano-Lamadrid et al., 2016; Zhu et al, 2015; Carbonell-Barrachina et al., 2015).

Conclusion

The almond is a traditional crop in Spain with a huge potential because of the high prices of the almonds fruits; for example, in 2015 the seedlings in the Spanish nurseries, including those in arid or semi-arid zones, were fully depleted and no plantlets were available. The implementation of RDI can be very important in reducing water deficit of the southeastern regions of Spain, one of the largest almond producing regions and with a huge demand due to the production of protected *turrón* (Jijona and Alicante) in the municipality of Xixona (Alicante). In this case, the „hydroSOS" brand could be perfectly related to the *turrón* industry, producing economic progress if hydroSOS almonds are used in the production of this Christmas dessert of great tradition and consumption, generating protected *turrón* environmental friendly. All information compiled in this review seems to prove that it is possible to produce high-quality almonds by reducing water consumption at specific growing stages and respecting the natural ecosystems.

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