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Deficit Irrigation as a Tool to Optimize Fruit Quality in Abbé Fetél Pear

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Abstract: Climate change is leading to higher plant water requirements and rootstock can play a role in tree adaptation, since the more vigorous ones are also likely to be more stress resistant. Pear trees of the cv. Abbé Fetél grafted on BA29 (more vigorous) and SYDO (more dwarfing) quince were irrigated according to three different treatments: 110 C, 80 DI and 60 DI, corresponding to 110%, 80% and 60% of the crop evapotranspiration rate (ETc), respectively. Shoot and fruit growth, water potentials, leaf gas exchanges and dry matter content were monitored during the season. Fruit quality was evaluated at harvest and after 6 months of storage at 1 °C. Results show how for both rootstocks, 60 DI significantly decreased their stem (Ψ_{stem}) and leaf (Ψ_{leaf}) water potentials as well as leaf gas exchanges. In SYDO, final fruit size was affected by irrigation, with lower values on 60 DI, but in BA29, no differences were found between treatments. After storage, BA29 60 DI fruit showed a higher soluble solid content, while in SYDO fruit, firmness was more affected by irrigation level. In conclusion, despite a slight decrease in fruit size, reduced irrigation led to fruit with higher quality features that were also maintained after a long period of storage.

Keywords: *Pyrus communis* L.; deficit irrigation; fruit quality; rootstock vigor; Abbé Fetél

Citation: Venturi, M.; Manfrini, L.; Perulli, G.D.; Boini, A.; Bresilla, K.; Corelli Grappadelli, L.; Morandi, B. Deficit Irrigation as a Tool to Optimize Fruit Quality in Abbé Fetél Pear. *Agronomy* **2021**, *11*, 1141. https://doi.org/10.3390/agronomy11061141

Academic Editor: Alejandro Galindo

Received: 20 May 2021
Accepted: 31 May 2021
Published: 3 June 2021

1. Introduction

Pear (*Pyrus communis* L.) is one of the major horticultural crops cultivated worldwide. Thanks to its potential long-term storage, fruit from cv. "Abbé Fetél" enables growers and retailers to furnish the market for several months after harvest. However, to maintain an adequate crop production, growers have to deal with the effects of climate changes [1], which are increasingly impacting perennial crop productions, especially in Mediterranean countries such as Spain, Greece and Italy [1,2]. In particular, reduced water availability represents one of the most worrying threats, especially in semi-arid areas [3]. When plants are subjected to drought periods, short- and long-term stress responses appear [4], and these physiological effects can be monitored and used as a reference to optimize orchard irrigation. As an example, a stem water potential threshold of −2 MPa has been proposed as reference value for drought stress in citrus to avoid conditions leading to lower yield and fruit quality [5]. The practice of applying a lower irrigation volume than the one evapotranspired by the plant is referred to as regulated deficit irrigation (RDI) and represents one of the promising adaptative strategies to increase water use efficiency in orchards [6] while reducing tree vegetative growth [7]. This reduced water supply showed no significant reductions in yield across many different crops [8]. Traditionally, water inputs are stopped after fruit harvest, since this practice does not seem to influence next-year fruit quality in 'Conference' pear [9], when an adequate stem water potential threshold is maintained. In this crop, irrigation can also be delayed until the beginning of the cell expansion stage, even though fruit cell division and enlargement could be negatively affected [10]. In jujube pear, the lack of water during the fruit maturation period does not affect total final production and its quality [11]. When drought stress occurs, the most immediate physiological response in woody plants is stomatal closure, which leads to reduced carbon assimilation. This also has negative effects on fruit vascular flows and thus on fruit development [12]. Pear fruit growth can be described by an expolinear model characterized by a first stage of cell division followed by a second stage of cell expansion [6].

Studies carried out on Abbé Fetél have shown how reductions in water supply first reduce the fruit xylem inflow and then the fruit phloem inflow, leading to a higher fruit dry matter accumulation even though harvest fruit size is reduced [13]. These trees progressively decreased their leaf gas exchanges along the season, although water shortage did not immediately affect their fruit phloem inflow [13]. Results reported by other studies also show how the application of deficit irrigation in pear increases soluble solids content but decreases fruit size [14–17]. Thanks to its high sugar and starch content, combined with low respiration rates, pear fruit is suitable for long periods of storage in a cold room with room temperatures close to 0 °C. As a matter of fact, Abbé Fetél pear is usually stored for up to six months in cold rooms, potentially also under modified atmosphere conditions [18]. However, prolonged periods of storage lead to fruit susceptibility to physiological disorders. One of the most common for Abbé Fétel is superficial scald, but problems such as soft scald and internal breakdown can also appear.

Deficit irrigation strategies can be used to reduce canopy growth [19–21], especially in high-density pear orchards and on vigorous rootstocks [22]. In vigorous rootstocks, most of the water and carbohydrates resources are partitioned to vegetative growth due to the higher sink strength of the growing shoots. Therefore, rootstock genotype and its interactions with the scion [23] should also be considered when applying reduced irrigation strategies [24], since tree water relations are widely affected by rootstock vigor [25]. In particular, dwarfing rootstocks usually show lower hydraulic conductivity and reduced root development with consequent lower stem water potentials [25,26]. These effects are known to affect source/sink relationships, carbon partitioning and thus fruit growth and quality [27].

It is well-known how drought stress negatively affects many plant physiological processes related to fruit growth and yield, although some studies show how it can also induce some potential benefits on certain fruit quality attributes [11,28–30]. The extent to which the latter are expressed, also depending on the rootstock vigor, is not clear. Therefore, correct water management may lead to improved fruit quality features, through precise and correct irrigation management. In this work, we hypothesize that a controlled drought stress might not heavily affect the main tree physiological processes, such as leaf gas exchanges and fruit development, while it can improve some fruit quality features such as soluble solids and dry matter content. The experiment reported here assesses the effects of different levels of reduced irrigation on water relations, leaf gas exchanges, fruit growth and fruit quality, both at harvest and after storage, on Abbé Fetél trees grafted on rootstocks with different vigor. Results can lead to the development of specific deficit irrigation protocols, allowing a trade-off between reduced physiological performance at tree level and an increase in intrinsic fruit quality.

2. Materials and Methods

2.1. Plant Material and Experimental Set Up

The trial was set up in two commercial pear orchards of the cv. Abbé Fetél, located in Poggio Renatico, Ferrara, Italy (44°77′69.59′′ N, 11°41′21.93′′ E). The first orchard was grafted on "BA29" while the second was grafted on "SYDO" quince. The orchards were located at about 100 m from each other; in both orchards, trees were trained at central leader, north-south oriented. Trees were spaced 4.0 × 1.30 m in the "BA29" plot and 3.8 × 1.0 m in the "SYDO" plot, with a total plant density of 1923 and 2631 trees ha^{-1}, respectively. Starting from 29 May 2017, three different irrigation levels were applied: standard irrigation at 110% of ETc (110 C), 80% (80 DI) and 60% (60 DI) of ETc, respectively (Table 1). Crop evapotranspiration rate was calculated according to the Irrinet irrigation scheduling system developed and made available by "Consorzio per il Canale Emiliano Romagnolo (CER)" of the Emilia-Romagna Region (www.irriframe.it, last accessed date: 2 June 2021). The environmental parameters needed as inputs were obtained from the closest weather station. Within each orchard, trees were homogeneous, and each irrigation treatment was applied to 8 trees within the same row, of which the outer two were used as buffer trees and the six central plants were considered in the trial. The sample set was kept limited as it is important to maintain as short as possible the measurement timings of the physiological parameters. Irrigation levels were set by modifying the distance between nozzles along the pipelines: 0.5, 0.7 and 1 m in the 110 C, 80 DI and 60 DI treatments, respectively. The flow rate of each nozzle was kept unvaried at 2.4 L/h. The irrigation amount was calculated for the 110 C treatment, and due to the different distance between the nozzles, each treatment received different amounts of water. Due to the different plant density, the irrigation timing for SYDO and for BA29 was different. Total precipitation amount from full bloom until fruit harvest was 112.6 mm. Soil features where homogeneous in the area considered and both orchards were managed according to standard cultural practices, with a standard fertilization of N-P-K equal to 90-30-100. Full bloom occurred on 25 March 2017, while harvest occurred on 31 August 2017, 159 days after full bloom (DAFB), for both orchards.

Table 1. Irrigation strategies applied during the field experiment.

Treatment	Phenological Stage	
	Full Bloom—Fruit Set (% ETc)	Fruit Set—Harvest (% ETc)
110 C	110%	110%
80 DI	110%	80%
60 DI	110%	60%

2.2. Water Relations

Stem and leaf water potentials (Ψ_{stem} and Ψ_{leaf}, respectively) were measured at 65, 80, 103, 129 and 159 DAFB, using a Scholander pressure chamber (Soilmoisture Equipment Corp., Goleta, Santa Barbara, CA, USA). On each date, measurements were carried out from 11.00 a.m. to 12.00 p.m. for SYDO and from 12.00 p.m. to 01.00 p.m. for BA29. To measure leaf water potential, one well-exposed leaf per tree (six leaves per treatment) was chosen and analyzed right after excision, following the protocol of Turner and Long (1980) [30]. To evaluate stem water potential, a leaf in the inner part of the canopy was chosen, as close as possible to the trunk. The selected leaf was then covered with an aluminum foil and enclosed in a plastic bag for at least 90 min to reach equilibrium, then its water potential was measured, just after excision, according to the methodology reported by McCutchan and Shackel (1992) and by Naor et al. (1995) [31,32].

2.3. Leaf Gas Exchanges

The main parameters considered within leaf gas exchanges were leaf assimilation, transpiration rate and stomatal conductance. Measures were performed simultaneously to water potential measurements, around midday, using an open-circuit infrared gas exchange analyzer fitted with a LED light source (Li-COR 6400, LI-COR, Lincoln, NE, USA) at 80, 103 and 129 DAFB. Measurements were carried out on one well-exposed leaf per tree, on six trees per treatment. During each measurement, light intensity was maintained constant setting the LED light source to the natural irradiance (which was always above 1200 μmols) experienced by the leaves immediately before the measurement, while air CO_2 concentration was set at 400 ppm.

2.4. Seasonal Fruit and Shoot Growth

Fruit growth was assessed on 6 representative, well-exposed fruit per tree placed on both sides of the row (with a total of 36 fruit per treatment), previously selected and tagged and then measured at 65, 80, 103 and 129 DAFB. In addition, on the same dates, shoot growth was measured on 4 previously tagged sprouts per tree, two on each side of the canopy, with a total of 24 shoots per treatment. Fruit growth rate was assessed by measuring fruit diameter variations along the vegetative season with a digital caliber equipped with a data logger, whereas shoot growth was assessed using a measuring tape. Thanks to the data collected, shoot absolute growth rate (AGR) was calculated at each recording time (t), using the following equation:

$$AGR\ t_1 = \frac{(M_t - M_{t-1})}{(t\ - (t-1))} \tag{1}$$

where M is measurement (shoot length), t is recording time and $t - 1$ is previous recording time.

The measurement unit is expressed as length increase over a fixed period, in this case days (cm day^{-1}).

2.5. Fruit Dry Matter Content

At 65, 103, 129 and 159 DAFB, ten fruit per treatment were collected and taken to the laboratory for dry matter analysis. This was determined by slicing the fruit and drying them at 65 °C in a ventilated oven until reaching constant weight. Weight measurements were performed on fresh and dried fruit portions. The rates of dry matter percentage were obtained as the relative ratio between dry and fresh weights of the sampled tissue.

2.6. Fruit Quality at Harvest

At harvest, 20 fruit per treatment were collected and immediately transported to the laboratory, where their average fruit weight, soluble solids content and fruit firmness were determined. All fruit were weighted using a digital scale, soluble solids content was determined by using a digital refractometer (Digital Hand-held PAL-1, produced by Atago) and a fruit texture analyzer (FTA, produced by GÜSS) was used to assess flesh firmness, after the removal of fruit skin. Two measurements were taken on two different sides, from each fruit, using an 11 mm probe.

2.7. Fruit Quality and Fruit Waste after Storage

Sixty additional fruit per treatment were also harvested and stored for six months in a cold room at 1 °C, at regular atmosphere conditions. At the end of the storage period, external physiological disorders and pathogen presence were photographed and recorded per each treatment. Disorder classification was performed thanks to literature bibliography. Then, total percentage of damaged fruit was calculated. The incidence of external disorders impeding fruit marketability was evaluated on 3 replicates of 20 fruit each. Furthermore, on the same samples, fruit quality assessment was performed as described above.

2.8. Data Analysis

Since plants on different rootstock received different irrigation amounts, statistical analysis was kept separated, analyzing together only the data within each rootstock plot. Data averages were separated among irrigation treatments through the analysis of variance (ANOVA). Within each rootstock, irrigation levels were compared through a SNK test. Analyses were performed using SAS statistical software.

3. Results

3.1. Water Relations

In both rootstocks, Ψ_{leaf} showed a variable trend during the season. In BA29, no differences among irrigation treatments were recorded during the whole season, except at harvest, when 60 DI showed a statistically significant reduction ($p < 0.05$) compared to 110 C and 80 DI, with a mean value of −1.86 MPa (Figure 1a). In SYDO, no differences between treatments were recorded during the season, but as a general trend, from 65 DAFB onwards, 110 C maintained the less negative Ψ_{leaf} values (Figure 1b). For both rootstocks,

Ψ_{stem} seasonal patterns were similar to the ones recorded on leaves: as before, in BA29, irrigation treatments did not induce any difference except at harvest, when 60 DI showed the most negative values (−1.40 MPa) (Figure 1c). In SYDO, 60 DI showed statistically significant ($p < 0.05$) lower Ψ_{stem} than 110 C and 80 DI treatments at 129 DAFB and at harvest, with values of −1.31 and −1.78 MPa, respectively (Figure 1d). No differences were detected between Ψ_{stem} from 110 C and 80 DI trees during the whole season.

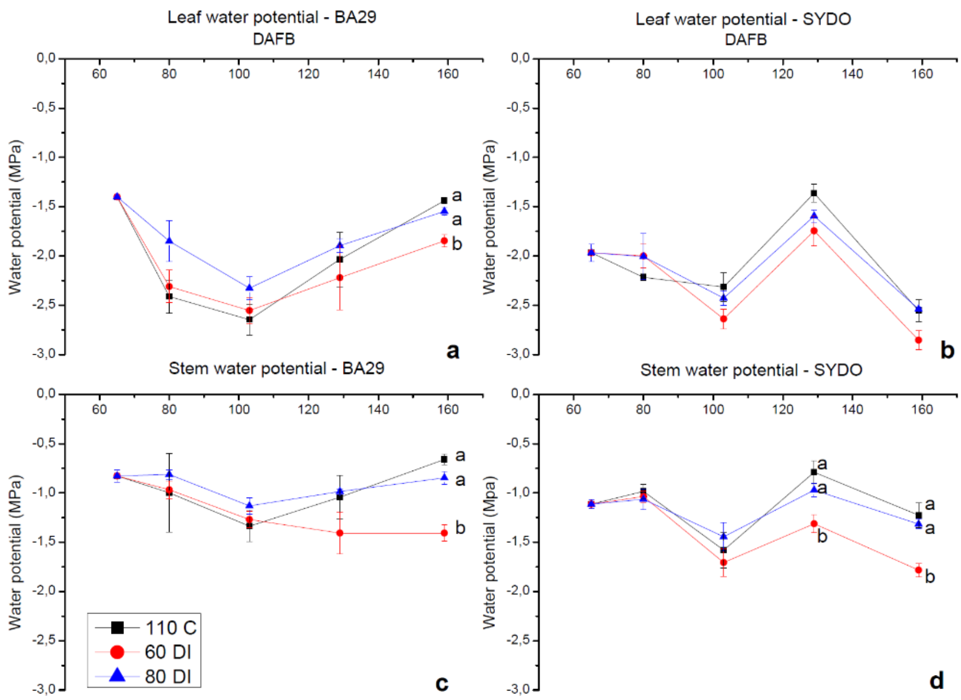

Figure 1. Seasonal patterns of midday leaf and stem water potential (MPa) in 110 C (■), 80 DI (▲) and 60 DI (●) irrigation treatments for trees grafted on BA29 (**a**,**c**) and SYDO (**b**,**d**) rootstocks. Each point represents the mean (±SE) value of 6 trees. On each monitoring day, means were separated using ANOVA, while treatments were compared using a SNK test. Letters indicate statistical DIfferences with $p < 0.05$.

3.2. Leaf Gas Exchanges

During the season, leaf stomatal conductance and transpiration showed increasing trends from 80 DAFB onwards (Figure 2). The increase in leaf transpiration was in agreement with the seasonal increase in average daily vapor pressure deficit (data not shown). In BA29, statistically significant differences ($p < 0.05$) between treatments were detected at 129 DAFB, when 110 C showed an average stomatal conductance of 0.27 mol H_2O m^{-2} s^{-1} vs. 0.19 mol H_2O m^{-2} s^{-1} of 60 DI. On the same day, differences were also detected on leaf transpiration, with 110% trees showing the highest values of 8.81 mmol m^{-2} s^{-1} (Figure 2c), while photosynthesis was affected both at 103 and 129 DAFB. At 103 DAFB, the highest photosynthetic value in BA29 (23.88 µmol CO_2 m^{-2} s^{-1}) was detected in 60 DI, while the lowest value was recorded in 110 C, with a rate of 20.57 µmol CO_2 m^{-2} s^{-1}. However, at 129 DAFB, treatments were inverted, and control treatments showed the highest photosynthetic rate, while the lowest photosynthetic rate (11.47 µmol CO_2 m^{-2} s^{-1}) was recorded on 60 DI trees. In SYDO, differences among treatments appeared only close to harvest, at 129 DAFB, when the 80 and 60 DI treatments presented statistically significant ($p < 0.05$) lower leaf gas exchanges than 110 C, both for stomatal conductance and leaf transpiration (Figure 2b,d). Leaf photosynthesis showed a similar behavior, with 80 and 60 DI treatments showing a 25% decrease compared to control (20.42 µmol CO_2 m^{-2} s^{-1} vs. 15.50 and 15.96 µmol CO_2 m^{-2} s^{-1}, respectively) (Figure 2f).

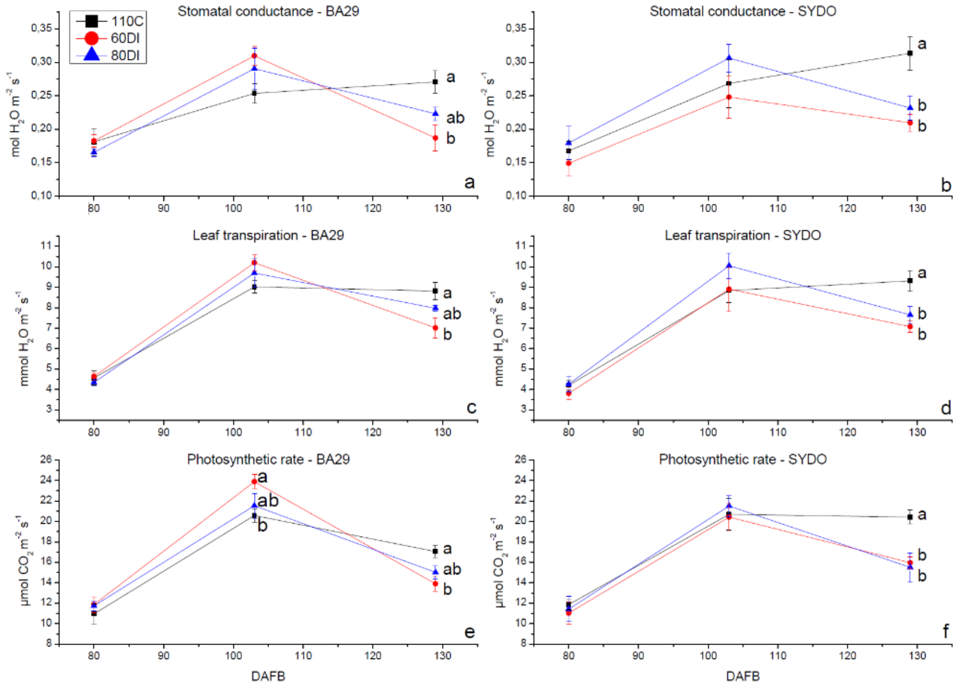

Figure 2. Seasonal pattern of stomatal conductance, leaf transpiration and photosynthetic rate in 110 C (■), 80 DI (▲) and 60 DI (●) irrigation treatments for trees grafted on BA29 (**a**,**c**,**e**) and on SYDO (**b**,**d**,**f**) rootstocks. Each point represents the mean (±SE) value of 6 trees. On each monitoring day, means were separated using ANOVA, while treatments were compared using a SNK test. Letters indicate statistical differences with $p < 0.05$.

3.3. Seasonal Shoot Growth

The differences in shoot growth between plants grafted on BA29 and SYDO were evident from the first measurement. While on SYDO trees shoot growth was limited, with a mean shoot length of 10 cm, in BA29, statistically significant differences ($p < 0.05$) were found between treatments during the whole season, with 80 DI showing longer shoots compared to 60 DI and 110 C treatments (Figure 3a,b). The absolute growth rate (AGR) of BA29 shoots followed a similar pattern, with the highest growth rate recorded at the beginning of the season in 80 DI (Figure 3c). On the contrary, in SYDO trees, shoot AGR maintained values below 0.2 mm day^{-1} during the season, with no differences between treatments (Figure 3d).

3.4. Seasonal Fruit Growth

The fruit growth pattern showed by BA29 led to similar final fruit size, with diameter values around 60–65 mm, regardless of the irrigation volume received (Figure 4a). In SYDO, a statistically significant difference ($p < 0.05$) between treatments was recorded both at the beginning (65 DAFB) and at the end (159 DAFB) of the season (Figure 4b). In SYDO, harvest fruit size was 71, 68.6 and 67.7 mm for 110 C, 80 DI and 60 DI trees respectively, and statistically significant differences ($p < 0.05$) were found between 110 C and 60 DI.

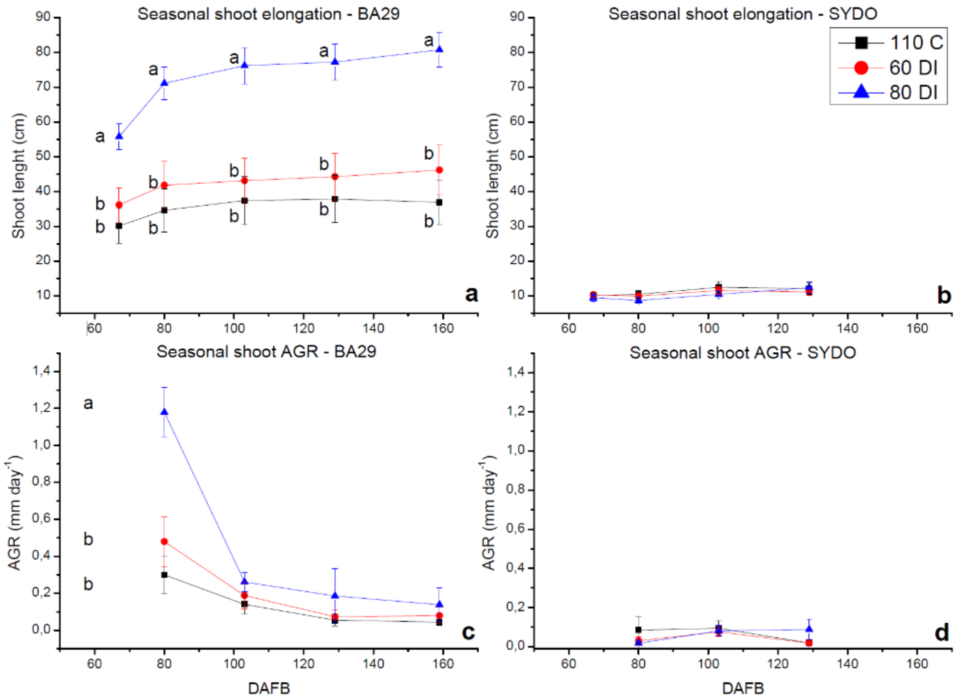

Figure 3. Seasonal pattern of average shoot length and shoot absolute growth rate (AGR) in 110 C (■), 80 DI (▲) and 60 DI (●) irrigation treatments for trees grafted on BA29 (**a**,**c**) and SYDO (**b**,**d**) rootstocks. Each point represents the mean (±SE) value of 24 shoots on 6 trees. On each monitoring day, means were separated using ANOVA, while treatments were compared using a SNK test. Letters indicate statistical differences with $p < 0.05$.

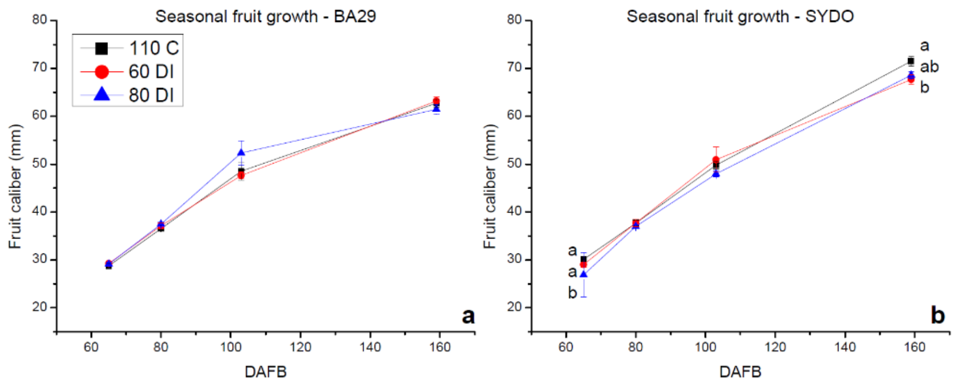

Figure 4. Seasonal pattern of average fruit diameter in 110 C (■), 80 DI (▲) and 60 DI (●) irrigation treatments for trees grafted on BA29 (**a**) and SYDO (**b**) rootstocks. Each point represents the mean (±SE) value of 36 fruit on 6 trees. On each monitoring day, means were separated using ANOVA, while treatments were compared using a SNK test. Letters indicate statistical differences with $p < 0.05$.

3.5. Fruit Dry Matter Accumulation

Fruit dry matter percentage decreased during the season until 129 DAFB and increased afterwards until harvest (Figure 5b). Even though the differences were not statistically significant, a general tendency of treatments receiving reduced irrigation to present a higher dry matter content can be noted, especially on SYDO trees.

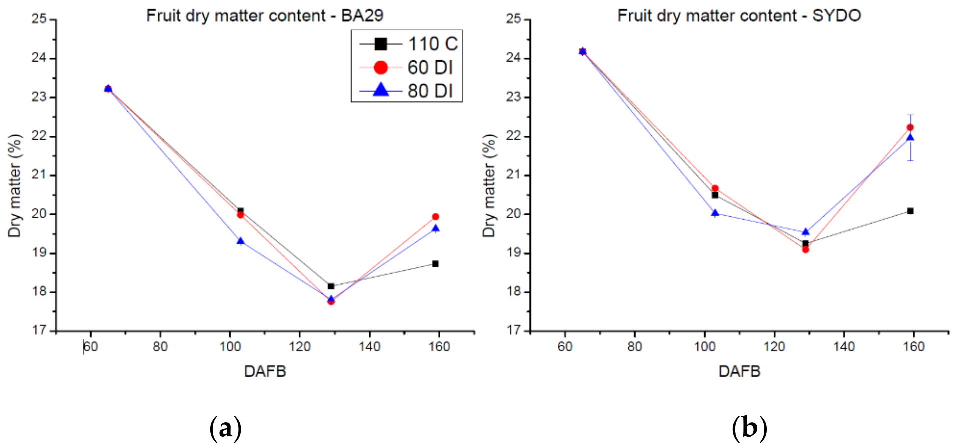

Figure 5. Seasonal pattern of fruit dry matter content in 110 C (■), 80 DI (▲) and 60 DI (●) irrigation treatments for trees grafted on BA29 (**a**) and on SYDO (**b**) rootstocks. Each point represents the mean (±SE) value of 10 fruits from 6 trees. On each monitoring day, means were separated using ANOVA, while treatments were compared using a SNK test.

3.6. Fruit Quality at Harvest and after Storage

At harvest, fruit from SYDO 110 C and 80 DI treatments showed higher weight compared to 60 DI (Table 2). Fruit flesh firmness and soluble solids content did not present differences induced by the irrigation volume applied, regardless of the rootstock. After storage, flesh firmness was not affected by the irrigation treatment in BA29, while in SYDO, 60 DI showed the lowest value, with a mean of 3.06 kg/cm^{-2}. Soluble solids content was affected by pre-harvest irrigation level on BA29: control fruit showed the lowest values (14.94° Brix), while the other treatments showed values above 16° Brix. SYDO fruit did not show significant differences in soluble solid content, but treatments maintained the same trend as those recorded in BA29.

Table 2. Fruit quality parameters at harvest and after six months of storage in 110 C, 80 DI and 60 DI irrigation treatments for trees grafted on BA29 and SYDO rootstocks. Each value represents the mean (±SE) value of at least 20 fruits from 6 trees. For each parameter, means were separated within each rootstock using ANOVA, while treatments were compared using a SNK test.

	Harvest			After Storage	
Treatment	**Weight (g)**	**Firmness (kg/cm^2)**	**SSC (° Brix)**	**Firmness (kg/cm^2)**	**SSC (° Brix)**
BA29 110 C	146.3 ± 10.0	6.19 ± 0.13	15.00 ± 0.13	3.16 ± 0.13	14.94 ± 0.65 b
BA29 80 DI	162.3 ± 9.17	6.05 ± 0.13	15.19 ± 0.46	3.22 ± 0.08	16.52 ± 0.30 a
BA29 60 DI	172.6 ± 8.69	6.23± 0.21	14.94 ± 0.44	3.18 ± 0.07	17.56 ± 0.26 a
SYDO 110 C	232 ± 9.72 a	6.29 ± 0.14	15.99 ± 0.26	3.47 ± 0.12 a	16.67 ± 0.39
SYDO 80 DI	241.9 ± 12.61 a	6.02 ± 0.09	15.93 ± 0.20	3.65 ± 0.09 a	16.7 ± 0.11
SYDO 60 DI	188.1 ± 11.29 b	6.07 ± 0.13	16.03 ± 0.15	3.06 ± 0.08 b	17.52 ± 0.33

a and b represent statistically significant DIfferences between treatments.

3.7. Fruit Waste after Storage

The percentage of fruit waste after 6 months of storage was not different among treatments in any of the rootstock tested (Figure 6). However, it can be noted that both in SYDO and BA29, 60 and 80 DI treatments showed lower percentages of incidence compared to 110 C, where instead, fruit showed the highest percentages of waste, with losses reaching 42.3% and 37.5% for BA29 and SYDO, respectively.

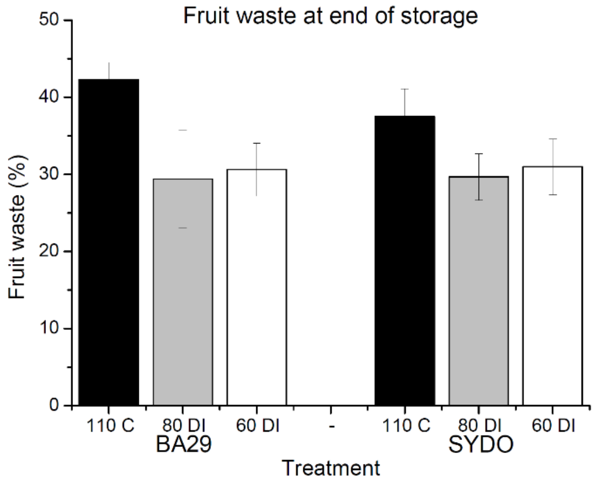

Figure 6. Fruit waste percentages at the end of the storage period in 110 C (black bar), 80 DI (grey bar) and 60 DI (white bar) irrigation treatments for trees grafted on BA29 and SYDO rootstocks. Each point represents the mean (±SE) value of at least 60 fruits from 6 trees. Means were separated using ANOVA, while treatments were compared using a SNK test.

4. Discussion

4.1. Plant Physiological Response to Water Stress

Stem water potential is considered a key physiological indicator for plant water status [4], and its sensitivity to water scarcity conditions in pear trees is well-known [3]. In both rootstocks, trees with different irrigation levels showed similar patterns in Ψ_{leaf} and Ψ_{stem} along the growing season, except at harvest, when 60 DI Ψ_{stem} was lower ($p < 0.05$) than 110 C, indicating the onset of stressful conditions (Figure 1c,d). This result suggests how, for both BA29 and SYDO orchards, irrigation could have been reduced at least by 30% during the whole season, and even by 50% in the earliest part of the season, without negative effects in tree water relations. Previous studies report how dwarfing rootstocks generally show higher decreases in stem water potentials [27] when subjected to drought stress, due to their lower hydraulic conductivity. A higher SYDO susceptibility to water restriction is confirmed by leaf gas exchanges results, where 80 DI showed a significant reduction in all parameters compared to 110 C at 129 DAFB, while on BA29, only 60 DI leaves' gas exchanges were affected (Figure 2a,b). Such higher stress sensitivity in SYDO trees might be due to several factors, including the reduction in the root system development typical of dwarfing rootstocks [33] as well as the general decrease in the hydraulic conductivity in correspondence to the grafting point. However, during the first part of the season, BA29 110 C were characterized by a general reduction in leaf transpiration, stomatal conductance and assimilation rate compared to 80 DI, that showed the best performance (Figure 2a,c,d). Although there were no data on soil water content, this result suggests how a 110% ETc irrigation might bring an excessive amount of water, leading to anoxic conditions for the root system and causing a decrease in the plant physiological performances. The very low assimilation rates recorded in both rootstocks at 80 DAFB might be due to low PAR and vapor pressure deficit conditions during that day of measurement. Shoot growth seemed to be only slightly affected by water deficit irrigation (Figure 3a,b). In fact, even though statistically significant differences ($p < 0.05$) were present from the beginning, our most vigorous rootstock (BA29) showed reductions in shoot elongations in 110 C and 60 DI treatments. These results are also coherent with final fruit size, where 80 DI fruit presented the lowest fruit size at harvest. On the other hand, with SYDO being a weaker rootstock, it showed a limited shoot growth and a higher carbon partitioning to fruit. This means that the rootstock plays an important role in the adaptation to stressful conditions. In fact, the more dwarfing rootstock SYDO showed a lower Ψ_{stem} earlier in the season than the more vigorous one, BA29. It should be also noted that applying a commercial irrigation could lead to the supply of water volumes higher than the plant needs.

4.2. Effects of Water Reduction on Fruit Quality

In SYDO, fruit size at harvest in 110 C was significantly higher ($p < 0.05$) than 60 DI fruit. However, all fruit were able to increase their diameter up to acceptable marketing values, even in the 60 DI, that were also characterized by increased fruit dry matter percentage, as a consequence of water limitations. In pear, water stress first affects xylem flow and then phloem flow [18]. This means that when the stress is moderate, for example in the 80 DI of this study, a lower amount of water enters the fruit, with no reductions in the amount of carbohydrates. This can explain the significant increase in dry matter with no important reductions in size (Figure 5a,b). Fruit dry matter content was even higher in 60 DI, both on SYDO and BA29, and this could be due to a further reduction in the fruit water inflows both from xylem and phloem, which led to the lower water content typical of stressed fruit [15]. In some apple cultivars, it was noted that a higher dry matter content was related to higher flesh firmness [34]. However, in this trial, no relations between fruit dry matter and flesh firmness were observed, providing more similar results to those found in pear and cactus pear [35,36]. Soluble solid content (SSC) represents another important quality parameter, highly related to fruit consumer acceptance (Table 1). In our trial, the irrigation level did not affect SSC at harvest, regardless of the treatment. This could be due to the time when commercial harvest normally occurs, several days before physiological ripening. At this stage, most fruit dry matter is stored under the form of starch, thus not affecting fruit SSC. However, after 6 months of storage, fruit showed a marked increase in SSC with statistically significant differences ($p < 0.05$) between BA29 110 C fruit (average value of 14.94° Brix) and 80 and 60 DI, reaching average values of 16.52 and 17.56° Brix, respectively (Table 1). At this stage, a higher amount of starch might have been converted into soluble carbohydrates, therefore it is likely that fruit with higher dry matter might have higher starch contents and higher potential for carbohydrate solubilization. In SYDO, differences between treatments are not statistically significant, but the same trend is maintained, with higher soluble solid contents in 60 DI. These data show how the positive effects of deficit irrigation on intrinsic fruit quality (sugar content) might be emphasized after a long period of storage, due to the climacteric ripening physiology of pear fruit.

4.3. Avoiding Fruit Waste Thanks to RDI Strategies

The market demand for a continuous fresh fruit supply throughout the year imposes the need to store fruit at cold temperatures for several months after harvest. However, prolonged storage periods can induce the appearance of physiological disorders (e.g., superficial scald), impeding the marketability of the product that will be discarded and thus wasted. Storability and physiological disorders are known to be affected by fruit calcium content [37], while calcium is transported only in the xylem [38,39]. Therefore, calcium absorption is reported to significantly decrease in drought stress conditions as this element moves along with the transpiration stream [40]. This could mean that a mild stress applied during the growing season can negatively affect fruit calcium content, thus decreasing its storage potential. However, this study found that fruit waste at the end of the storage period was lower in 60 and 80 DI treatments, concluding that in this case, a reduction in the irrigation water applied had a positive effect on the onset of storage disorders (Figure 6).

5. Conclusions

The results reported in this work confirm the hypothesis that a mild drought stress can allow to reach improved fruit quality features without negatively affecting plant physiological performance. In particular, we can conclude that, in our experimental conditions, an 80% ETc reduced irrigation can be successfully applied to pear along the whole growing season, since trees did not show any decrease in their physiological performance, regardless of the type of rootstock. Moreover, a controlled deficit irrigation might not significantly reduce fruit size, but rather increase fruit quality in terms of soluble solids content and even potential storability. This could mean that adequate irrigation management can lead to a better fruit quality, that if maintained during storage and provided to the market, reduces the discarded fruit percentage, also increasing the generated income along the supply chain. These results lead to a general conclusion that new irrigation protocols can be developed in pear, with the aim to increase fruit quality while improving water use efficiency.

Author Contributions: Conceptualization, B.M., L.M. and L.C.G.; methodology, B.M. and L.M.; investigation, M.V., A.B., G.D.P., K.B., L.M. and B.M.; data curation, M.V. and B.M.; writing—original draft preparation, M.V.; writing—review and editing, B.M.; supervision, B.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research has been partly funded by APOFRUIT Soc. Cooperative (Italy).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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