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Deficit Irrigation Regime Improves Phytosanitary Status of Cultivar Arbosana Grown in a Super High-Density Olive Orchard

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Abstract: Super high-density (SHD) planting systems are very efficient in terms of production and water use. In these orchards, water-saving irrigation strategies are used precisely to keep the best sustainability compared to traditional orchards. With agro-climatic and eco-physiological parameter monitoring, the SHD planting system has become even more efficient. SHD orchards, however, could also be more so affected by other pests and diseases than traditional systems, but field responses are still unknown when olive trees are grown in SHD groves. The goal of this two-year field research was to investigate the seasonal changes of the phytosanitary status of 'Arbosana' grown in an SHD orchard under both regulated deficit (RDI) and full irrigation regimes (FI). This study investigated the influence of the two different irrigation regimes on the infections of three olive tree key diseases: cercosporiosis (*Pseudocercospora cladosporioides*), cycloconium (*Fusicladium oleagineum*), and olive knot (*Pseudomonas savastanoi* pv. *savastanoi*). RDI significantly reduced the severity of cercosporiosis in 2020 compared to FI but not in 2021. Cycloconium was observed only as a latent infection during the two studied years and olive knot was not influenced by irrigation but only by weather conditions. These findings suggest that irrigation management can play a key role in controlling cercosporiosis effectively in SHD olive orchards, but also that weather conditions have an even higher impact on the tree key diseases.

Keywords: cercosporiosis; cycloconium; olive knot; McKinney index; severity of symptoms index; disease spread index

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1. Introduction

Super high-density (SHD) olive orchards were born in Spain in 1994 and have spread rapidly throughout all olive-growing areas [1]. This cropping system is based on some agronomic assumptions which include continuous canopy, very high planting density (from 1200 to 2000 trees ha^{-1}), reduced tree growth, high and constant productivity, early bearing, and the use of machines for the integral pruning and harvesting machines [2–4]. The SHD growing system is the most popular for new olive orchard plantations, both in the most cultivated areas and in the newest vocated areas, like Argentina, Australia, and the USA [5]. These new plantations are highly efficient: just 3.3% of global olive orchards produce 36% of the world's extra-virgin olive oil [6].

Therefore, this can be obtained using medium-to-low vigor cultivars, such as 'Arbequina', 'Arbosana' and new patented genotypes, such as 'Chiquitita' [7], 'Oliana' and 'Lecciana' [8], all compatible with hedgerow groves and fitting for the straddle harvesting machines [1]. 'Arbosana' was the first one used and is still a reference cultivar for SHD olive orchards, best adapted to this cultivation system, due to its markedly low vigor and good constant yield [9] making it one of the cultivars widely planted in SHD orchards worldwide [8,10,11]. Apulia is the Italian region where 60% of SHD Italian olive orchards are concentrated [12]. An innovative approach to olive growing is increasingly necessary.

Moreover, it is of high relevance to know the varietal behavior in the current climatic conditions where water is in short supply and, due to climate change, will be worse every year [13]. For this reason, it is mandatory to apply techniques that can increase water efficiency, which could represent the use of cultivars with a higher recovery [14] or the application of deficit irrigation strategies.

Regulated deficit irrigation (RDI) is a strategic approach to irrigation that involves applying water below the full crop water requirements during certain growth stages, aiming to enhance water use efficiency without significantly affecting crop yield and quality [15]. The best period chosen to practice this stress in olives is in pit hardening; this phase is less sensitive to water stress as the plant has reduced fruit growth and vegetative activity [16,17]. This regime is particularly beneficial for tree species, which are often more tolerant to water stress than annual crops. RDI significantly enhances water use efficiency, with potential increases in water productivity by 10–50% depending on the species and deficit level [18]. In olive orchards, a 20–40% decrement in irrigation water applied under RDI, compared to full irrigation (FI), had little impact on the physiological response of the olive trees over the course of the season [19–22].

However, in olive trees, RDI has been shown to influence plant physiology and enhance natural defense mechanisms, leading to a reduction in plant diseases. Specifically, RDI improves water-use efficiency and induces physiological stress, which can activate the production of phenolic compounds and lignin in olive tissues [23,24]. These compounds play a key role in plant defense by strengthening cell walls and creating physical and chemical barriers against pathogens. Additionally, RDI reduces excessive vegetative growth, which can limit the favorable microclimates for pathogen development within the tree canopy, reducing disease incidence [24]. Studies have demonstrated that olive trees subjected to RDI produce higher levels of these defensive compounds, leading to increased resistance to diseases like *Verticillium* wilt and other fungal infections [25]. The Mediterranean climate can strongly affect both the adaptation of different tree species [26] and micro-organism proliferation [27]. *Pseudocercospora cladosporioides* (Sacc.) Braun, the etiological agent of the olive cercosporiosis, can be found in all olive-growing areas of the Mediterranean basin, California, Argentina, Brazil and Australia and seems to be attracting new interest due to its increasingly intense spread and the high level of damage it causes [28–30].

Fusicladium oleagineum (Castagne) Ritschel and U. Braun, a demiaceous hyphal fungus etiological agent of the cycloconium, can be found in all Italian olive-growing areas and its severity depends mostly on the local climatic conditions [31–33].

The bacterium responsible for the olive knot disease is *Pseudomonas savastanoi* pv *savastanoi* (Van Hall), and its symptoms may be aggravated by the presence and subsequent synergy with *Erwinia oleae*. The species is an epiphytic bacterium that could be found in all olive-growing areas and can cause several infections depending on field situations, assuming different economic importance. [34–36]. Infections of *Pseudomonas* assume, based on the type of attack and location of the organ, different economic importance, that are not well defined, as the plant, although weakened, survives the aggression of the bacterium [37].

Different irrigation regimes can influence the susceptibility of olive trees to pests and diseases. Irrigation and growing systems play a relevant role in the main olive phytophagy, influencing their impact both on traditional and SHD orchards [38]. Frequent irrigation, especially daily watering, has been shown to increase the incidence and severity of *Verticillium* wilt in susceptible olive cultivars like 'Picual' [39]. Conversely, deficit irrigation strategies, which involve reduced water application, can help maintain plant health and reduce disease severity by limiting excessive soil moisture that favors pathogen proliferation [40].

Until now, no research has been performed on the influence of irrigation on population diseases in SHD olive orchards. Therefore, the goal of this field research was to determine the occurrence of the three olive key diseases in an adult SHD olive orchard under two different irrigation regimes (RDI and FI) under the typical Mediterranean environment. Disease monitoring was conducted in 2020 and 2021 by analyzing leaves for cercosporiosis and cycloconium infections, while twigs were inspected for olive knots. The hypothesis to verify was that RDI, beyond being useful in water saving, can reduce phytopathological problems assuring less treatment and, consequently, a significant economic and environmental increase in the sustainability of olive growing intensification.

2. Materials and Methods

2.1. Site and Orchard

The experimental orchard was located at Valenzano (Apulia-Southern Italy; 41°01′ N; 16°45′ E; 110 m a.s.l.) in the "Centro Didattico-Sperimentale Martucci" of the University of Bari. The SHD olive grove of 'Arbosana' was planted in 2006; trees were trained according to the central leader system, with a tree spacing of 4.0 m × 1.5 m apart (1667 trees/ha) and North-South row orientation. The soil was sandy clay classified as typical haploxeralf (USDA) or chromium cutaneous Luvisol (FAO). The site has a typical Mediterranean climate with an average annual rainfall (1998–2018) of 560 mm, of which two-thirds occur in the autumn and winter months. The long-term average annual temperature is 15.6 °C.

During the two years of data collecting (2020 and 2021), the olive trees were pruned once, in March 2020. The fertilization was carried out with 84 kg/ha of N, 54 kg/ha of P_2O_5 and 47 kg/ha of K_2O each year. Common best practices (soil management and pest control practices) were set up. The disease control followed the Integrated Pest Management (IPM) guidelines of Regione Puglia and consisted of: one treatment with 3 kg/ha of Mancozeb 75 WDG fungicide during spring, treatment with 1.5 kg/ha of Fosmet insecticide during summer (only in 2020), and one treatment with 1.5 kg/ha of 75% copper oxide during December, in both years.

2.2. Experimental Layout and Irrigation Regimes

Two plots of 180 m^2, with 35 trees/plot, were selected and subjected to two different irrigation treatments, as detailed in Ferrara et al. [19]: full irrigation (FI), and regulated deficit irrigation (RDI). RDI was applied during the pit hardening, as the phenological phase when the olive tree is less sensitive to water deficit [41]; during this period the irrigation was interrupted for just over a month a year (15 July–18 August 2020; 14 July–14 August 2021). Irrigation was scheduled following the evapotranspiration method, by restoring 100% of crop evapotranspiration (ETc) lost in each irrigation interval. ETc was calculated using the FAO 56 guideline [42]. The mean seasonal irrigation volumes were 438 mm and 317 mm for FI and RDI, respectively; the RDI trees received 22% and 33% less water with respect to FI trees, during the first (2020), and second (2021) seasons, respectively [19]. In these two adjacent plots, the presence of pathogens was monitored in 2020 and 2021.

2.3. Disease Monitoring

All disease surveys were carried out directly in the field, except for early diagnosis of cycloconium. Ten trees in each plot were randomly selected, and then a visual analysis of symptoms was carried out for each tree. To determine the sample size, the binomial proportion sampling formula for estimating disease incidence was used [43].

Ten and five old leaves (older than one year) and ten and five young leaves (younger than one year), respectively, for cercosporiosis and cycloconium were observed by sampling and selected through all dimensions of the canopy (the four cardinal points, top and bottom as well as the inner and outer parts of the canopy). For each leaf, the presence or absence of cycloconium symptoms was observed and recorded as explained below.

For cercosporiosis (*Pseudocercospora cladosporioides* (Sacc.) Braun), the sampling was carried out in the periods that the literature suggests as typical for the maximum spread and expression [29,44] in winter-early spring (from 26 February to 5 April 2021), in summer (June 2021) and in late autumn-early winter (from 15 November to 15 December 2021), always before phytosanitary treatments. The development of the disease was analyzed by assigning at each leaf a level based on the percentage of leaf area compromised by the pathogen (plumage on the lower page and/or chlorosis on the upper page): 0 is considered healthy leaf; 1 is less than 10%; 2 is between 11–30%; 3 is between 31–50%; 4 thus for a leaf that is covered for more than 50% of the leaf area.

For cycloconium (*Fusicladium oleagineum* (Castagne) Ritschel and U. Braun), the number of spots present on the leaves was monitored during the periods from February to March, June, and December, using an empirical scale to categorize disease severity. The scale includes the following classes: 0 for a healthy leaf, 1 for a single spot, 2 for two spots, 3 for three spots, 4 for 4–6 spots, and 5 for more than 6 spots per leaf. Additionally, an early diagnostic test was conducted on a sample of asymptomatic leaves in October to detect the quiescent infection and the potential spread of the disease. This test involved immersing the leaf samples in a 5% NaOH solution for 2–4 min at room temperature for young leaves (less than one-year-old) or at 55–60 °C for older leaves (more than one year old).

For the olive knot (*Pseudomonas savastanoi* pv. *savastanoi* (Van Hall)), the number of tubercles present on a 20–50 cm segment of five branches, aged between 1 and 2 years, was counted. A total of 167 tubercles were found and it was then directly used to assess the severity of the disease. The margin of error for the monitoring of the disease was minimal for the following reasons: (i) the symptom expression of cercosporiosis, cycloconium, and olive knot is well-characterized and exhibit low variability; (ii) these diseases are widespread in the region where the investigation was conducted; (iii) they occur with medium to high frequency almost every year, albeit with varying incidence depending on climatic conditions. Furthermore, the sample size used in the experiments was sufficient to minimize the risk of data misinterpretation.

2.4. Disease Indexes

After collecting all the data, the McKinney Index (I), the Severity of Symptoms (G), and the Disease Spread (D) were calculated for each tre/e using the following formulas:

$$\mathrm{I} = \frac{\sum(\mathrm{c} * \mathrm{f})}{\mathrm{N} * \mathrm{V}} 100,$$

where c is the class of disease (0, 1, 2, 3, 4, 5) observed on the samples; f is the frequency of the class considered; N the total number of leaves examined; V the maximum value present in the class. I express the level of disease reached in relation to the maximum attainable (100%). The maximum level of disease would be reached when it finds the maximum level on the disease scale in all the observations.

$$\mathrm{G} = \sum(\mathrm{c} * \mathrm{f})/\mathrm{n},$$

where c and f are the same as for the I index; n is the number of diseased leaves. G index indicates the disease average intensity observed on the diseased samples.

$$\mathrm{D} = \mathrm{n}{*}100/\mathrm{N}$$

where n is the same as for the G index; N is the total number of leaves examined. D index indicates the percentage of symptomatic cases (infected leaves out of the total number of examined leaves).

2.5. Statistical Analysis

Using R Studio 2023.12.1, disease indexes were calculated for each of the studied pathogens, in the two studied years (2020 and 2021), through the two irrigation strategies (FI and RDI). Shapiro tests were conducted over each pathogen index dataset to verify the normality of the distribution of the data. When the data were normally distributed, two-way ANOVA with interaction analysis was performed using "aov()" function followed by the Tukey post hoc test (function HSD.test). Instead, when there was no normally distribution Kruskal–Wallis analysis was performed followed by the Dunn test (function dunn.test). The considered variables were years (2020 and 2021) and irrigation strategies (FI and RDI). Letters indicate statistical differences for each index among treatments and years with level of significance $p < 0.05$. To better represent the data, mean and standard deviation were calculated for each of the variable's combination and graphics were created using ggplot on R Studio.

2.6. Agroclimatic Pattern

Air temperature and precipitation were collected at a standard agrometeorological station 120 m away from the experimental field. The experimental periods were characterized by very different weather, including the extreme water scarcity conditions during the 2021 drought summer, and the exceptionally rainy summer in 2020 characterized by few events and high rain intensity, confirming the great variability following the climate change, in terms both of temperature and rain over the last number of years in this Mediterranean area [45–47]. The yearly mean air temperature was 18.1, 16.4 and 17.0 °C in 2019, 2020 and 2021, respectively, being always warmer than in the past (15.6 °C). The air temperature was also well above the mean of the period in June 2019. Furthermore, an intense heat wave crossed the experimental field during the summer of 2021, between the end of July and the beginning of August, when irrigation was withheld in the RDI plot. Mean air temperature attained 34 °C and peaks of 42 °C were observed during daytime.

3. Results

3.1. Cyclosporiasis

Different irrigation levels responded differently to infestations during 2020 but not in 2021 (Figure 1, Table S1). In 2020, the FI treatment was associated with a higher McKinney Index (I) and Severity of Symptoms (G) compared to RDI. The I and G values were notably higher under FI (35.00% for I and 2.31% for G) compared to RDI (24.20% for I and 1.66% for G), suggesting that full irrigation may promote conditions that favour the proliferation of *Pseudocercospora* (Table 1). The percentage of infected leaves (D) was also slightly higher under FI (61.70) compared to RDI (58.30), although this difference was not statistically significant.

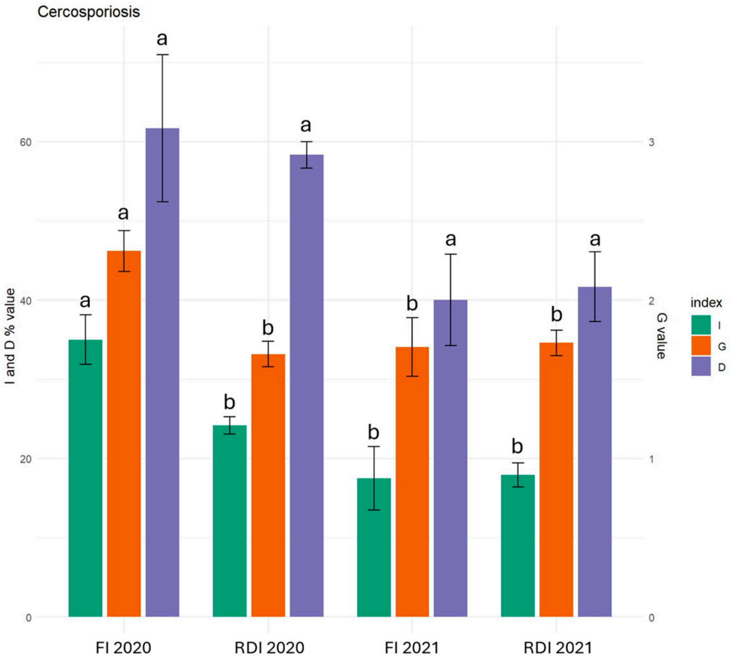

Figure 1. McKinney Index (I), Severity of Symptoms (G) and Disease Spread (D) indexes of cercosporiosis for 'Arbosana' full irrigated (FI) and regulated deficit irrigated (RDI) during 2020 and 2021. SD bars are also reported. Letters indicate significant statistical differences ($p < 0.05$) for each index among treatments and years.

Table 1. Two-way ANOVA with interaction of the influence of cercosporiosis infection (<0.01, '**'; <0.05, '*'; <0.1 ',') for McKinney Index (I), Severity of Symptoms (G) and Disease Spread (D) indexes.

Index	Df	Sum Sq	Mean Sq	F Value	Pr (>F)
I					
irrigation	1	81.40	81.40	3.676	0.09148 ,
year	1	423.00	423.00	19.112	0.00238 **
interaction	3	94.90	94.90	4.288	0.07214 ,
residuals	8	177.10	22.10		
G					
irrigation	1	0.2908	0.2908	6.094	0.0388 *
year	1	0.2149	0.2149	4.504	0.0666 ,
interaction	3	0.3433	0.3433	7.197	0.0278 *
residuals	8	0.3817			
D					
irrigation	1	2.1	2.1	0.02	0.8921
year	1	1102.1	1102.1	10.373	0.0122 *
interaction	3	18.8	18.8	0.176	0.6855
residuals	8	850	106.2		

The year-to-year variation in disease severity, with 2021 showing lower levels of infection across both irrigation regimes, highlighted the influence of environmental conditions on cercosporiosis. The McKinney index and symptom severity were lower than in 2020, with no significant differences between FI and RDI (17.5 and 17.9%, respectively). The reduction in disease severity in 2021 could be attributed to different environmental conditions that were less favourable for the development of cercosporiosis during that year.

The ANOVA indicated that the year had a significant impact on disease outcomes, with 2020 showing higher disease levels than 2021 (Table 1). The interaction between irrigation regime and year was also significant for some variables, suggesting that the effect of irrigation on cercosporiosis is influenced by yearly variations.

3.2. *Cycloconium*

The monitoring of cycloconium on the 'Arbosana' revealed the absence of visible disease symptoms during both years. However, an early diagnostic test conducted in October detected the presence of the pathogen on the leaves, although without the expression of symptoms. The study also sought to determine whether the irrigation regimes had any impact on the presence of *Fusicladium*. However, the data showed that the pathogen's presence (D) in the early diagnostic tests did not significantly differ between the two irrigation regimes, indicating that irrigation practices may not have a substantial influence on the latent fungal presence when the environmental conditions are not favourable for symptom development.

3.3. *Olive Knot*

In 2020, despite conditions that might generally favor pathogen proliferation—such as higher rainfall and moderate temperatures—the incidence and severity of olive knots were significantly lower compared to 2021 (Figure 2, Table S2). D, G and I were lower under both FI and RDI treatments. Conversely, in 2021, despite experiencing hotter and drier conditions, there was a marked increase in olive knot severity.

I, G and D indices were slightly higher under FI than RDI but none of these differences were significant (Table 2). Specifically in 2020, the FI treatment resulted in 26.7% of branches being infected compared to 19% under RDI. The G was also higher for FI (2.22) compared to RDI (1.78) like D which was 86.7% in FI and 73.3% in RDI. However, these differences, while notable, were not statistically significant, suggesting that other factors may also play a role in disease expression. In 2021, both the incidence and severity of olive knots increased in both irrigation regimes, with FI showing a more pronounced effect. The percentage of infected branches reached 50.5% under FI and 47.6% under RDI, while the G rose to 3.53 for FI and 3.33 for RDI. The differences between the two irrigation regimes were less pronounced in 2021, indicating that environmental factors, such as temperature and humidity, may have had a stronger influence on disease progression during that year. Indeed, ANOVA and Kruskal–Wallis results showed that the year was a significant factor affecting disease severity and incidence, with 2021 showing higher levels than 2020.

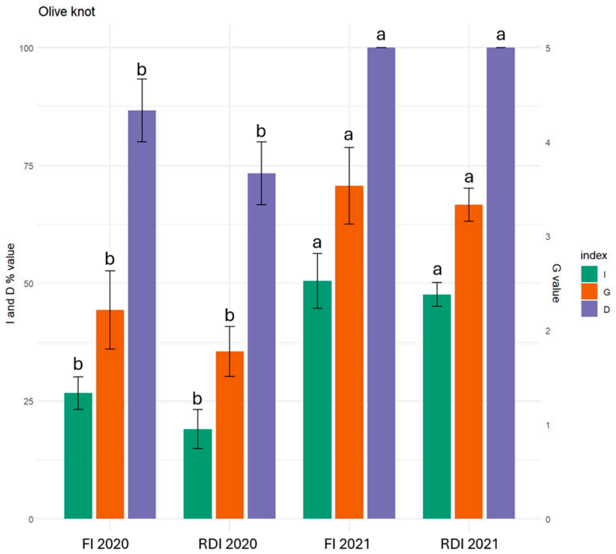

Figure 2. McKinney Index (I), Severity of Symptoms (G) and Disease Spread (D) indexes of Olive Knot disease for 'Arbosana' full irrigated (FI) and regulated deficit irrigated (RDI) during 2020 and 2021. SD bars are also reported. Letters indicate significant statistical differences ($p < 0.05$) for each index among treatments and years.

Table 2. Two-way ANOVA with the interaction of the influence of olive knot disease infection (<0.001, '***'; <0.01, '**'; <0.05, '*') for McKinney Index (I) and Severity of Symptoms (G) indices; Kruskal–Wallis analysis of the interaction of the influence of olive knot disease (<0.001, '***'; <0.01, '**'; <0.05, '*') for Disease Spread (D) index.

I	Df	Sum Sq	Mean Sq	F Value	Pr (>F)
Irrigation	1	82.3	82.3	1.592	0.24257
year	1	2057.8	2057.8	39.803	0.000231 ***
Interaction	3	17	17	0.329	0.58204
Residuals	8	413.6	51.7		
G					
Irrigation	1	0.306	0.306	0.933	0.36249
year	1	6.187	6.187	18.847	0.00247 **
Interaction	3	0.043	0.043	0.13	0.72739
Residuals	8	2.626	0.328		
D	**Df**	**chi-squared**	***p*-value**		
Irrigation	1	0.53333	0.4652		
year	1	7.5	0.00617 **		
Interaction	3	8.5667	0.03564 *		

4. Discussion

Irrigation management can act as a driving force in a super-intensive olive grove, leading to various benefits [48]. Moreover, the interaction between irrigation and bacterial pathogens or fungal communities is complex and is influenced by the host genotypes [49].

Cycloconium, cercosporiosis, and olive knot were selected as the focus of the experiments due to their widespread occurrence in the region where the investigations took place.

These diseases appear with medium to high frequency almost every year, though their incidence varies depending on climatic conditions. Moreover, these three diseases account for the majority of phytosanitary interventions, and the associated costs of treatments, as well as the resulting yield reductions, can reach significant levels.

To the best of the author's knowledge, no study has ever been published on the influence of irrigation level on these three olive diseases, even more so in SHD olive orchards. No comparisons with other studies could be made considering the novelty of the work. Under Mediterranean climatic conditions, *Pseudocercospora* is becoming more and more relevant, due to its increasingly intense spread and the high level of damage it causes, especially considering that damage is also caused on young leaves and not only onto those over a year old, which in the past were considered more susceptible to it. Symptomatology is mainly concentrated in the lower part of the foliage and on mature leaves [29,30]. 'Arbosana' exhibited different levels of sensitivity to cercosporiosis infections over the two years (Figure 1). FI treatment generally resulted in higher levels of I and G compared to RDI, particularly in 2020 (Table S1). The biology of *Pseudocercospora* provides a foundation for understanding the observed disease patterns. The higher humidity associated with FI could promote fungal growth and conidia production, consistent with the findings of Govi [50], who noted that *Pseudocercospora* thrives under moist conditions. In contrast, the RDI treatment, which imposes water stress during specific growth phases, might limit the favourable conditions for *Pseudocercospora* development. Water stress can reduce humidity levels, creating a less favourable environment for fungal growth and conidiation [50]. This could explain the lower disease incidence and severity observed under RDI. Furthermore, the exceptionally rainy summer in 2020 likely contributed to the higher disease levels observed that year, as consistent rainfall can prolong leaf wetness periods, providing ideal conditions for *Pseudocercospora* infection and spread [51]. Conversely, the heatwave and drier conditions in 2021, particularly during the summer, would have reduced the duration of leaf wetness and potentially hindered fungal development, resulting in lower disease severity. It is notable that also in previous research, on other fungal diseases, a higher level of irrigation led to higher levels of population [52,53]. Cycloconium has a characteristic behaviour: the infected leaves remain on the tree for a variable period, but eventually fall off prematurely; before dropping off, the old leaves turn yellow, followed by a bright leathery red coloration [54,55]. In this orchard, 'Arbosana' showed no visible cycloconium symptoms in either year, but early diagnostic tests detected the pathogen on leaves without symptoms. This suggests 'Arbosana' may have higher resistance to this fungus than other cultivars, harbouring the pathogen without developing symptoms (unpublished data). Irrigation regimes did not significantly affect cycloconium presence in early tests. This fungus thrives in high humidity and rainfall, conditions typically met in Mediterranean autumn and spring. Despite pathogen presence, symptom absence could be due to unfavourable weather conditions in 2021 (dry, hot summer) and 'Arbosana' resistance mechanisms. *Fusicladium* requires 12–24 °C (optimally 20 °C) for conidial germination [56]. The year 2021's extreme temperatures likely inhibited symptom development. Plant defence mechanisms, including phenolic compounds like oleuropein, can confine the fungus to external subcuticular areas [57].

In 2020, higher rainfall and milder temperatures were more favourable for fungal activity, yet no symptoms appeared, further indicating 'Arbosana' resistance. This suggests fungal activity is primarily driven by climate rather than soil moisture from irrigation. While full irrigation might create a humid microclimate, symptom expression seems more tied to broader environmental conditions. To the best of the author's knowledge, no data have been published yet on 'Arbosana″s lower susceptibility to cycloconium.

The overall trend of olive knot infections remained consistent, with a slight increase in disease severity observed in the final survey of 2021 (Figure 2). This increase was likely exacerbated by mechanical injuries caused by strong winds and rain in the months leading up to the last analysis [58–60]. Such injuries provide entry points for the pathogen, facilitating infection and disease progression, particularly in trees that are more vulnerable due to their irrigation regime. The incidence and severity of olive knots were influenced by both the irrigation regimes and the specific environmental conditions during the study years of 2020 and 2021 (Table S2). It is already known that high humidity, prolonged wetting of the plant organs and temperatures fluctuating around 22–25 °C are favorable conditions for the bacterium, which can cause new infections by penetrating the natural openings into the tree and the lesions caused by pruning, frost damage, wind damage, harvesting and all mechanical damage in general [35,36]. The data reveal a nuanced interaction between these factors, with disease progression particularly linked to mechanical injuries and environmental stressors. The higher disease severity under FI, particularly in 2021, could be linked to the physiological conditions created by full irrigation. Well-hydrated tissues, particularly in the FI treatment, may be more susceptible to mechanical injuries, such as those caused by wind and rain, which can facilitate the entry of the pathogen. Additionally, the denser canopy in FI-treated trees may create a microclimate conducive to pathogen survival and spread. These injuries are critical in facilitating the entry of bacteria, particularly when the trees are already under stress from adverse weather conditions [37]. On the contrary, RDI treatment imposed controlled water stress [19] that likely led to less dense canopies and more resilient tissues, reducing the incidence of mechanical damage. This could explain the lower disease levels observed under RDI, even during the more challenging conditions of 2021, even if they are not statistically significant.

5. Conclusions

The results of this two-year study demonstrated that the regulated deficit irrigation (RDI) regime can positively influence the phytosanitary status of ‘Arbosana’ olive trees grown in a super high-density (SHD) orchard, especially in relation to cercosporiosis. In 2020, RDI reduced the severity and spread of cercosporiosis compared to full irrigation (FI), likely due to less favourable moisture conditions for fungal development. However, this effect was not observed in 2021, highlighting the significant role of weather conditions, particularly rainfall and humidity, in disease expression.

For cycloconium, no visible symptoms were observed during either year, though early diagnostic tests revealed latent infection. This suggests that ‘Arbosana’ may possess a high degree of resistance to cycloconium, irrespective of the irrigation regime.

Olive knot infections were slightly more prevalent under FI, but the differences between irrigation treatments were not statistically significant. Environmental factors, such as mechanical damage caused by strong winds and rain, played a critical role in disease progression, particularly in the challenging conditions of 2021.

Overall, this work provides interesting information about a theme yet not explored, being the first of its kind. In this climate change context, it is more and more important to reach the best agronomic results, also reducing irrigation if possible. These findings suggest that RDI not only offers water-saving benefits but also contributes to a reduced incidence of certain diseases, enhancing the sustainability and economic viability of SHD olive orchards. Nonetheless, climatic conditions remain a key driver of disease outbreaks, and the careful monitoring of agro-environmental factors is essential for optimizing both irrigation strategies and disease management in SHD systems. Further insights are needed by repeating the same observations on different cultivars, with different growth behaviour and with different susceptibilities to the studied diseases. Moreover, correlation analysis between climatic variables and disease incidence or severity on a more long-term trial could be performed.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agronomy14102380/s1.

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