Low- and high-frequency irrigation of Radicchio "Rosso di Treviso"

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Abstract

Radicchio (Cichorium Intybus L., group Rubifolium) is a plant widely cultivated in Italy to sell the leafy heads. Veneto is one of the Italian regions with the largest share of Radicchio cultivation. Radicchio "Rosso di Treviso" is one of the more cultivated varieties, but scientific knowledge about the most appropriate irrigation management is still limited. The study focuses on the effect of two irrigation scheduling criteria on Radicchio yield and on the number of marketable plants, in a field experiment carried out from 2013 to 2017 in a commercial farm in Veneto (North-East Italy). Mini-sprinkler system was set to provide water from the transplanting for most of the cropping period, with a low-frequency schedule, and a high-frequency schedule that doubled the number of interventions but halved the water volumes applied each time. The total volumes of water applied each year were the same in both treatments. At harvest, 7 sample areas were randomly harvested and (i) marketable yield, (ii) average head weight and (iii) number of marketable plants were measured. Overall, the high-frequency schedule produced 26.5 t ha^{-1} of marketable Radicchio heads, while the low-frequency schedule 23.6 t ha^{-1}, significant variability was found between years. The greater productivity was mainly the result of a greater number of marketable plants, while the average head weight was not significantly different between the treatments. This suggests that a greater irrigation interval can create less favorable conditions for Radicchio yield, increasing the number of underweight, rotten and missing plants. Farmers should take into account the possibility to increase irrigation frequency if the eventual higher management cost does not offset the gain in Radicchio productivity.

Keywords: mini-sprinkler irrigation system; marketable yield; number of marketable heads; irrigation frequency.

INTRODUCTION

Radicchio (Cichorium Intybus L., group Rubifolium) is cultivated in Italy for selling the leafy heads. 42% of the Italian Radicchio production takes place in Veneto region. Among the different varieties cultivated in Veneto, the most common are "Rosso di Chioggia", "Rosso di Verona", "Variegato di Castelfranco" and "Rosso di Treviso". "Rosso di Treviso" is particularly important for the farmers of Treviso and Venice district, where the cultivation is protected by the IGP ("Indicazione Geografica Protetta") trademark, assigned by the European Union. Even though Radicchio is appreciated for its culinary characteristics and for the high nutritional values, research on several features of its cultivation is still limited (Nicoletto and Pimpini, 2009).

Irrigation of Radicchio is of primary importance to achieve sufficient productive levels (Monti et al., 2005), but large variations in Radicchio yield can result from the management of the irrigation volumes and scheduling (Patel et al., 2000). A wide varieties of irrigation techniques are commonly applied in Radicchio cultivation, usually starting right after transplanting. These

techniques can range for example from furrow (Filippini et al., 2011) to sprinkler irrigation (Bortolini et al., 2016) or surface and subsurface drip irrigation (Babik et al., 2009). Mini-sprinklers offer the possibility to adapt the irrigation scheduling to the crop needs, taking into account some peculiar features of Radicchio cultivation, like the need to apply large amounts of water during great part of the cropping period, avoiding at the same time the creation of adverse growth conditions (e.g. soil crust and waterlogging, as highlighted in Bortolini et al., 2016).

For these reasons, a field trial to test the effects of two different mini-sprinkler irrigation scheduling on "Rosso di Treviso" yield was carried out in a commercial farm in Veneto during 2013-201.

MATERIAL AND METHODS

Experimental site

The experiment was carried out in open field in the commercial farm "Mion" of Venice district (north-eastern Italy). Radicchio (Cichorium intybus L., group Rubifolium) "Rosso di Treviso" was cultivated from 2013 to 2017, but due to extremely rainy conditions, the cultivation did not take place in 2014, so that a total of 4 years of data was collected.

Meteorological data (air temperature at 2 m above ground level and rainfall) was collected from the nearby weather station of the regional agency for the environmental protection "ARPAV". Weather data characterizing the growing period was graphically analyzed and interpreted.

Irrigation treatments

Two irrigation treatments were tested in this study: (i) a low-frequency irrigation scheduling and (ii) a high-frequency irrigation scheduling. The two treatments differed in the frequency, but not in the total water volumes applied. In the low-frequency treatment water was applied ones every four days and in the high-frequency treatment ones every two: the number of irrigations was doubled respect to the other treatment, but the water volumes applied each time were halved.

The irrigation system (Fig. 1) was the same in both treatments: low-volume mini-sprinklers "Super10" (NaanDanJain Irrigation Ltd., Israel), with a nominal flow rate 530 L h^{-1} at 3.5 bar, placed 10-m apart.

Agronomic management

Radicchio was transplanted on seedbeds during the first half of August each year, and harvested at the end of October / beginning of November. 15-cm-high seedbeds were prepared according to Bortolini and Bietresato (2016), to provide the most favorable conditions for plants growth. Plant spacing was 0.6 m between the rows and 0.26 m on the row, for a total of 6.41 plants m^{-2}. 100 kg N ha^{-1} in the form of ammonium nitrate were applied before transplanting. P and K content in the soil was sufficient to support Radicchio growth, so that no additional fertilizer was applied.

Harvest and data analysis

At the end of each growing period, 7 randomly-allocated sample areas (of 3.744 m^2) were harvested in each field per each treatment. (i) Total marketable yield, (ii) average head weight and (iii) total number of non-marketable plants were measured in the sample areas.

ANOVA was used to detect the effects of year, irrigation frequency and their interaction on the measured variables. Post-hoc pairwise comparison (Tukey HSD test) was performed to spot significant differences between the low- and high-frequency treatments within each year. All statistical analysis was performed using R software (R Core Team, 2018).

Fig. 1. Mini-sprinkler irrigation during the first stages of Radicchio growth

RESULTS

Annual weather and annual production

Rainfall, minimum and maximum temperature were recorded during the cropping season of each year (Fig. 2). An impact of the weather trend (year effect) on Radicchio growth emerged from the analysis of variance.

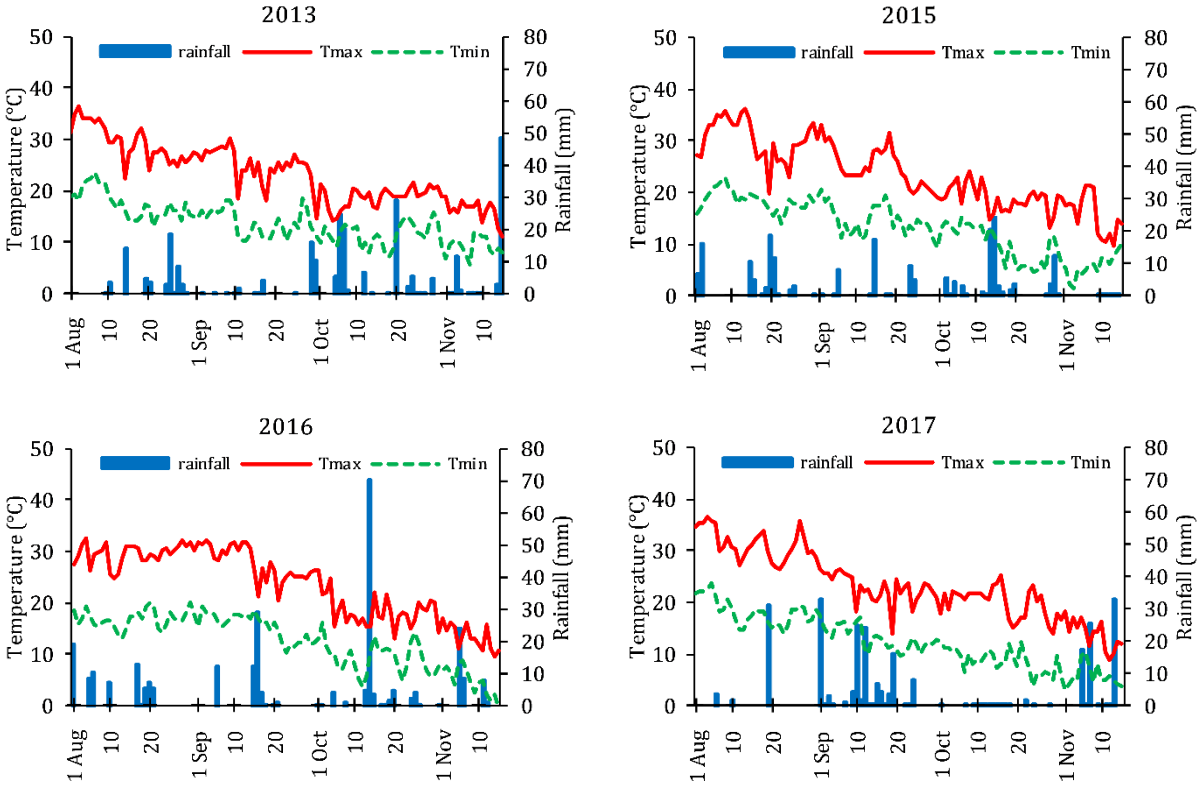

Fig. 2. Rainfall, maximum and minimum temperature (1 August – 15 November) during the growing period for 2013, 2015, 2016 and 2017.

The least productive year was 2016 (with 20.4 t ha^{-1} on average), whose cropping period was characterized by 214 mm of rainfall, with a peak event of 70 mm in October. Temperatures were lower than in other years, and a more sensitive temperature drop was recorded in October and November. Rainfall was more homogeneously distributed during the cropping period of 2013 (152 mm), 2015 (183 mm) and 2017 (218 mm). 2015 was the most productive year (with an average of 28.8 t ha^{-1}), while 2017 showed the greatest variability in marketable yield, with a greater range in the low-frequency irrigation treatment.

Irrigation frequency effects on yield factors

Yield factors of each year are detailed in Table 1, and the effects of irrigation scheduling are highlighted. Overall, the low-frequency irrigation scheduling marketable yield averaged 23.6 t ha^{-1}, while the high-frequency scheduling averaged 26.5 t ha^{-1} (that is 12% more). The general positive effect of the high-frequency irrigation on Radicchio yield was considered significant by the analysis of variance. As for head weight, the average weight was 0.46 kg/head with high-frequency irrigation, and 0.44 kg/head with the low-frequency irrigation, but no statistical difference was highlighted by the ANOVA (even though the p-value of 0.07 was approaching the conventional threshold of significance). More favorable growing conditions were reported in the high-frequency treatment in regards to the number of marketable plants (on average 56,853 plants ha^{-1}, vs. 53,896 plants ha^{-1} of the low-frequency treatment, with an overall p-value < 0.05).

The effect of the irrigation treatment was further investigated within each year: significant differences were highlighted for marketable yield in 2013, for average head weight in 2016 and for the number of marketable plants in 2017. In all the cases, the high-frequency irrigation showed better growing conditions than the low-frequency scheduling, even though in 2016 and 2017 this did not determine a significantly higher productivity.

In light of this, it can be safely assumed that the greater marketable heads productivity of the high-frequency treatment was primarily influenced by the number of marketable plants that were found at harvest, and only secondarily by the average head weight. The high-frequency scheduling showed to be more profitable when in the low-frequency treatment the number of missing, underweight and rotten plants was greater, and Radicchio heads that could still be considered marketable did not grow enough to compensate for the defective production. Indeed, Radicchio needs a great water supply since the transplant into the field, but may also be particularly sensitive to the soil growing conditions that can be affected by the irrigation interval (e.g. with formation of soil crust and waterlogging) (Bortolini et al., 2016).

Table 1. Yield factors measured per each year and irrigation frequency (average ± st. dev.). Different letters indicate significant differences within the same year.

	marketable yield (t ha^{-1})		average head weight (kg)		marketable plants (nr. ha^{-1})	
frequency	**low**	**high**	**low**	**high**	**low**	**high**
year						
2013	21.3 ± 2.6 ^{b}	25.6 ± 2.3 ^{a}	0.39 ± 0.03 ^{a}	0.44 ± 0.04 ^{a}	55327 ± 5915 ^{a}	58761 ± 4876 ^{a}
2015	27.9 ± 2.6 ^{a}	29.7 ± 3.4 ^{a}	0.48 ± 0.05 ^{a}	0.50 ± 0.04 ^{a}	57998 ± 2972 ^{a}	59905 ± 4038 ^{a}
2016	18.7 ± 1.8 ^{a}	22.1 ± 2.4 ^{a}	0.36 ± 0.03 ^{b}	0.44 ± 0.04 ^{a}	51511 ± 2541 ^{a}	50747 ± 3777 ^{a}
2017	26.6 ± 7.1 ^{a}	28.5 ± 4.7 ^{a}	0.52 ± 0.09 ^{a}	0.49 ± 0.07 ^{a}	50748 ± 6168 ^{b}	57997 ± 2019 ^{a}

CONCLUSIONS

The present study showed that a proper management of a mini-sprinkler irrigation schedule can positively affect Radicchio yield. Specifically, this study indicated that:

- Even if the water volumes applied with irrigation were adequate to avoid drought stress, adopting a higher-frequency irrigation schedule increased Radicchio yield.

- A higher number of marketable plants was obtained with a higher-frequency irrigation schedule.
- Overall, despite year-by-year differences, the greater Radicchio yield (due to better irrigation scheduling) was favored primarily by a higher number of marketable heads found at harvest, rather than by the average weight of each head.

In conclusion, it should be reminded that the irrigation scheduling must meet the needs of the farmer. If the eventual cost of increasing irrigation frequency is offset by the higher productivity, a higher-frequency irrigation scheduling is advisable. It is also not unfair to assume that these findings could be applied to other varieties of Radicchio too, even though further research is still needed.

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