Olive Oil Composition of Cv. Cobrançosa Is Affected by Regulated and Sustained Deficit Irrigation

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Abstract: The aim of this study was to evaluate the effect of different irrigation strategies on cv. Cobrançosa olive oil main components, in a semiarid region in the Northeast of Portugal (Alfândega da Fé, 2019)—regulated (RDI) and sustained deficit (SDI) irrigation against well-irrigated controls (FW). Total polyphenols (Folin) were higher in RDI than SDI and FW treatments. Among the phenolic components, hydroxytyrosol and tyrosol derivatives (HPLC, after acid hydrolysis), were higher in olive oils obtained under SDI, potentially complying with the nutrition allegation allowed in Regulation (EU) No 432/2012, ("polyphenols in olive oil contribute to the protection of blood lipids against undesirable oxidation"), while the amounts in FI120 and RDI100 olive oils were 10% lower to the threshold. Olive oil vitamin E (mainly α-tocopherol) was also higher in oils obtained from SDI deficit irrigation treatments while oils from RDI had values very close to FI treatments. Olive oil bitterness, evaluated by K225, was highly positively correlated with TP ($r^2 = 0.94$, $p < 0.01$). The fatty acidy profile was not affect by the irrigation regime. Results are preliminary and need to be continued to extract solid conclusions.

Keywords: irrigation; extra-virgin olive oil; biophenols; vitamin E; oil bitterness

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Material and Methods

- Conducted in the season of 2019 in a 25-years-old commercial olive orchard (6 m x 6 m) located at Vilariça Valley, Northeast of Portugal;

- Six irrigation treatments were tested: (i) full irrigated (fi) equivalent to 100% of estimated evapotranspiration (ET); over full irrigated (FI_{120}) that received 120% of estimated ET; (iii) two sustained deficit irrigation (SDI) with 60% (SDI_{60}) and 30% (SDI_{30}) of FI, and (iv) two regulated deficit irrigation, one irrigated equally to FI (RDI_{100}) except in the pit hardening period in which irrigation was reduced to 10%, and in the other, irrigation was cut off at pit hardening period;

- Plant water status was evaluated periodically by shoot water potential and relative water content according to the methodology reported [1];

- Irrigation started at June 16^{th} and stopped at October 1^{th}, and olive trees were irrigated with a drip line emitters (± 4 L/h).

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Material and Methods

- Harvest was performed at the end of November;

- Oil extraction by the system Oliomio (Oliomio 50) hammer mild;

- The Paste underwent malaxation at room temperature for 30 min and the oil extracted with a two-phase decanter;

- The olive oils (samples) were put in 750 mL dark glass and stored in the dark at room temperature;

- Analysis were carried out after 50 months of extraction. Assays were carried out in triplicate.

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Material and Methods

- Evaluation of quality parameters, standard method [2];
- Index K_{225}, method described by [3];
- Polyphenol Content; method described by [4];
- Phenolic compounds from olive oils extracted and analysed according to the method proposed by [5] with some modifications according to [6];
- Vitamin E Content; method described by [7];
- Fatty Acids Composition; determined following the European Community Regulation EEC/2568/91 from 11th July [2].

Results

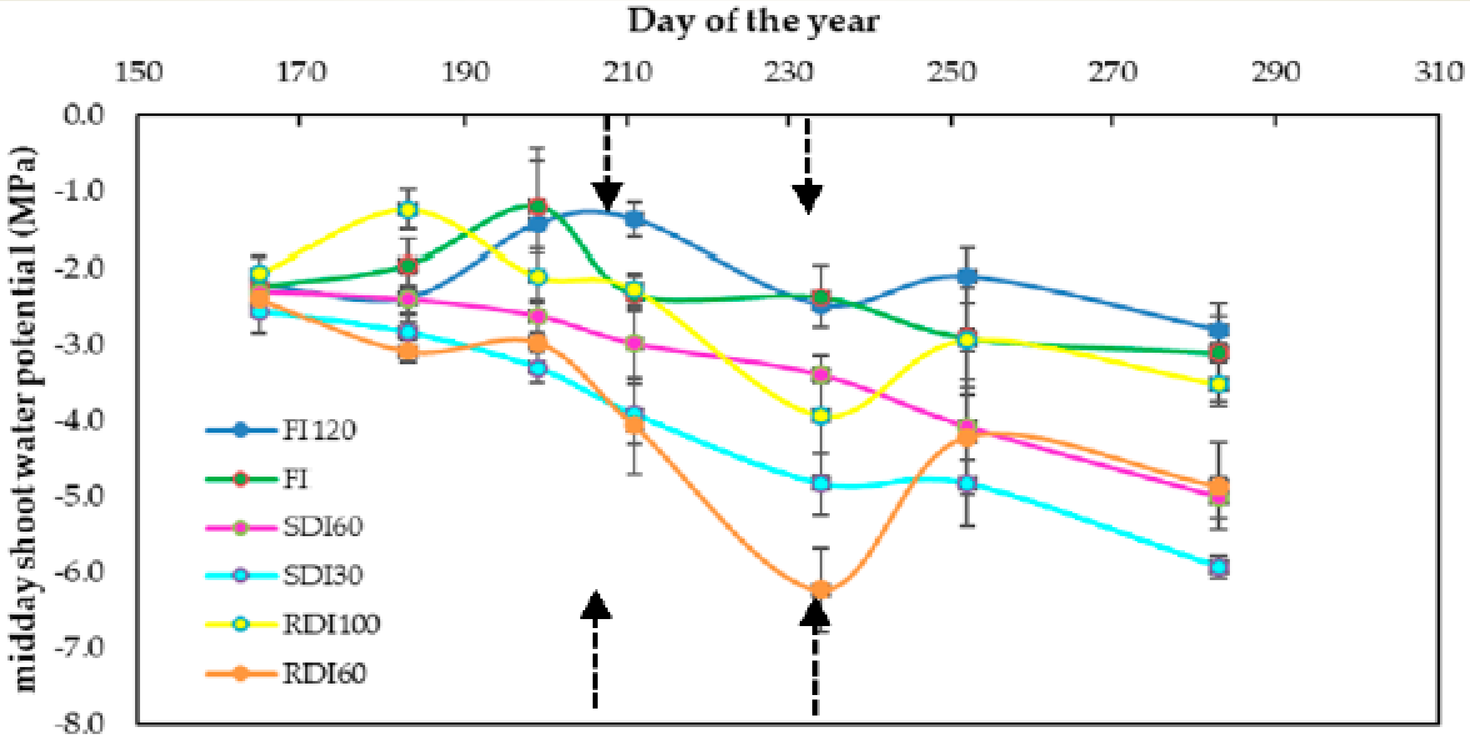

Figure 1. Seasonal time course of midday shoot water potential (ΨMD) for FI-full irrigation, FI120-40 over full irrigation, sustained deficit irrigation (SDI30 and SDI60) and regulated deficit irrigation (RDI100 and RDI60) treatments during the irrigation season of 2019 (mean ± standard deviation, n = 1 3). The arrows indicated the period of irrigation cut of in RDI60 and irrigation reduction in RDI100.

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Results

Table 1. Mean values of relative water content (RWC, %) for FI-full irrigation, FI_{120}-over full irrigation, sustained deficit irrigation (SDI_{30} and SDI_{60}) and regulated deficit irrigation (RDI_{100} and RDI_{60}) treatments during the irrigation season of 2019 (mean ± standard deviation, n = 5).

Treat.	Day of the Year (from June 14th to October 25th)							
	165	183	211	234	240	252	283	298
FI_{120}	92.9 ± 0.8	89.5 ± 3.2	87.8 ± 1.1	91.5 ± 2.5	91.3 ± 2.5	88.1 ± 3.4	88.5 ± 1.8	95.7 ± 1.0
FI	94.5 ± 1.8	90.0 ± 2.3	89.5 ± 1.5	90.5 ± 1.8	88.9 ± 0.9	90.2 ± 0.7	85.9 ± 3.5	95.2 ± 1.7
SDI_{60}	91.4 ± 2.9	86.2 ± 5.0	85.5 ± 4.0	82.7 ± 0.8	89.7 ± 2.1	80.8 ± 1.1	76.4 ± 1.6	96.8 ± 0.6
SDI_{30}	90.7 ± 1.6	81.4 ± 3.5	73.5 ± 4.7	71.5 ± 5.2	82.6 ± 5.2	68.7 ± 5.1	61.9 ± 5.1	95.2 ± 1.7
RDI_{100}	93.0 ± 1.1	91.4 ± 0.3	86.7 ± 2.1	85.0 ± 2.6	90 ± 1.8	91.4 ± 5.8	84.1 ± 3.1	96.1 ± 2.7
RDI_{60}	92.6 ± 1.1	86.8 ± 2.3	79.3± 3.0	70.8 ± 4.4	88.6 ± 2.4	79.6 ± 6.0	72.2 ± 6.7	93.1 ± 1.8

Table 2. Free acidity (% oleic acid), peroxide value (mEq O_2/kg), specific extinction coefficients (K_{232} and K_{270}) and bitterness index (K_{225}) of olive oils obtained from olives produced from different irrigation strategies during the year 2019 (mean ± standard deviation).

Treatment	Free Acidity	Peroxide value	K_{232}	K_{270}	K_{225}
FI	0.32 ± 0.01	9.0 ± 0.2	1.50 ± 0.27	0.07 ± 0.02	0.31 ± 0.01
FI_{120}	0.31 ± 0.01	7.4 ± 0.2	1.40 ± 0.11	0.08 ± 0.00	0.12 ± 0.01
SDI_{60}	0.27 ± 0.01	5.6 ± 0.2	1.25 ± 0.43	0.08 ± 0.02	0.43 ± 0.03
SDI_{30}	0.18 ± 0.01	5.4 ± 0.2	1.26 ± 0.33	0.08 ± 0.01	0.21 ± 0.01
RDI_{100}	0.23 ± 0.01	7.0 ± 0.3	1.25 ± 0.06	0.08 ± 0.01	0.40 ± 0.00
RDI_{60}	0.25 ± 0.01	5.3 ± 0.2	1.17 ± 0.44	0.06 ± 0.02	0.45 ± 0.00

[1] FI-full irrigation, FI_{120}-over full irrigation; sustained deficit irrigations (SDI_{30} and SDI_{60}) and regulated deficit irrigations (RDI_{100} and RDI_{60}).

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Results

Table 3. Total phenols (mg of gallic acid equivalent/kg of olive oil), vitamin E (mg/kg of olive oil), concentrations of hydroxytyrosol (mg of hydroxytyrosol equivalent/kg of olive oil) and tyrosol (mg of tyrosol equivalent/kg of olive oil), and amounts of the sum of both compounds (mg/20 g of oil) after the secoiridoids' acid hydrolysis and determined by HPLC-DAD (280 nm) of olive oils obtained from olives produced from different irrigation strategies during the year 2019 (mean ± standard deviation).

Treatment	Total Polyphenolics	Vitamin E	Hydroxytyrosol	Tyrosol	Hydroxytyrosol + Tyrosol
FI	611.9 ± 12.6	269.2 ± 1.7	128.0 ± 4.6	118.6 ± 0.9	4.7 ± 0.1
FI_{120}	462.6 ± 21.3	296.0 ± 8.4	122.9 ± 1.4	113.2 ± 1.5	4.9 ± 0.0
SDI_{60}	677.4 ± 17.7	309.2 ± 5.0	139.0 ± 3.0	143.7 ± 0.5	5.7 ± 0.1
SDI_{30}	548.6 ± 19.3	314.8 ± 0.6	178.6 ± 4.6	155.4 ± 3.3	6.7 ± 0.2
RDI_{100}	735.7 ± 22.9	266.3 ± 3.0	106.8 ± 0.9	123.2 ± 1.0	4.6 ± 0.0
RDI_{60}	762.1 ± 20.5	280.3 ± 2.0	51.4 ± 1.0	46.3 ± 0.1	2.0 ±0.0

FI-full irrigation, FI_{120}-over full irrigation; sustained deficit irrigations (SDI_{30} and SDI_{60}) and regulated deficit irrigations (RDI_{100} and RDI_{60}).

Table 4. Concentration (%) of the main fatty acid, palmitic acid ($C_{16:0}$); oleic acid ($C_{18:1}$), linoleic acid ($C_{18:2}$), ratio of the total unsaturated to saturated fatty acid (UFA/SAT) and ratio of monounsaturated to polyunsaturated fatty acid of olive oils obtained from olives produced from different irrigation strategies during the year 2019 (mean ± standard deviation).

Treatment	$C_{16:0}$	$C_{18:1}$	$C_{18:2}$	UFA/SAT	MUFA/PUFA
FI	12.7 ± 0.1	71.3 ± 0.1	8.7 ± 0.0	4.7 ± 0.0	7.6 ± 0.0
F_{120}	12.6 ± 0.1	72.4 ± 0.1	8.0 ± 0.0	4.8 ± 0.0	8.3 ± 0.0
SDI_{60}	11.3 ± 0.0	72.1 ± 0.1	8.4 ± 0.0	4.8 ± 0.0	7.9 ± 0.0
SDI_{30}	11.0 ± 0.0	72.1 ± 0.1	8.9 ± 0.1	5.0 ± 0.0	7.5 ± 0.1
RDI_{100}	11.7 ± 0.4	71.8 ± 0.3	8.8 ± 0.1	4.9 ± 0.1	7.6 ± 0.0
RDI_{60}	11.1 ± 0.0	72.7 ± 0.1	8.3 ± 0.1	4.9 ± 0.0	8.1 ± 0.1

FI-full irrigation, FI_{120}-over full irrigation; sustained deficit irrigations (SDI_{30} and SDI_{60}) and regulated deficit irrigations (RDI_{100} and RDI_{60}).

Discussion

- Some treatments suffered moderate or severe water stress (low values for RWC and ΨMD) due reduction or cut off water sourcing during summer (SDI_{30}) or pit hardening period (RDI_{100} and RDI_{60}), but after irrigation reestablishment, olive trees recovered quickly water status;

- Free acidity didn’t show a consistently trend with plant water status;

- Peroxyde values (PVs) showed a tendency to decrease with water deficit, in line with reported in other studies [8,9];

- Olive oil bitterness (K_{225} parameter), showed a general decrease with water applied, similar reported by [10].

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Discussion

- Total polyphenols increased with water déficit as they área secondary metabolites that are synthetized by plants to protection of free radicals;

- Vitamin E content didn’t show a pattern with plant status;

- The obtained results of hydroxytyrosol and tyrosol derivates perhaps can be influenced by the occurrence of the drought during oil biosynthesis as RDI_{60} had lowest values while SDI strategies had the highest;

- The fatty acid composition didn’t show a consistent behavior with irrigation treatments.

Conclusions

- Irrigation cut-off strategies (RDI) and sustained deficit irrigation (SDI) affected the total polyphenols, being the EVOO from RDI richer than SDI;
- Individuals phenols, hydroxytyrosol and tyrosol derivatives were higher in EVOO from both SDI than EVOO from FI and RDI strategies;
- The preliminary results are interesting and should be investigated in order to extract solid conclusions to forward in choosing the irrigation strategy and to obtain a better relation between water use efficiency, oil yield and their properties (quality).

Acknowledgments

- **Acknowledgments:** Authors are very grateful to the farmer Manuel António Afonso for the allowing to develop this study.

- **Funding:** This work was funded by Project Olive Oil Operational Group—SustentOlive: Improvement of irrigation and fertilization practices at olive farms in Trás-os-Montes for its sustainability (PDR2020-101-032178), financed by the European Agricultural Fund for Rural Development (EAFRD) and Portuguese State under Ação 1.1 «Grupos Operacionais», integrada na Medida 1. «Inovação» do PDR 2020—Programa de Desenvolvimento Rural do Continente. This work was developed with collaboration of National Funds by FCT—Portuguese Foundation for Science and Technology [project UIDB/04033/2020] and also with REQUIMTE (NORTE-01-0145-FEDER-LAQV; UIDB/50006/2020).

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