

VOL IX

AGRÁRIAS

PESQUISA E INOVAÇÃO NAS CIÊNCIAS QUE
ALIMENTAM O MUNDO

EDUARDO EUGÊNIO
SPERS
(Organizador)

 EDITORA
ARTEMIS

2023

VOL IX

AGRÁRIAS

PESQUISA E INOVAÇÃO NAS CIÊNCIAS QUE
ALIMENTAM O MUNDO

EDUARDO EUGÊNIO
SPERS
(Organizador)

 EDITORA
ARTEMIS

2023



O conteúdo deste livro está licenciado sob uma Licença de Atribuição Creative Commons Atribuição-Não-Comercial NãoDerivativos 4.0 Internacional (CC BY-NC-ND 4.0). Direitos para esta edição cedidos à Editora Artemis pelos autores. Permitido o download da obra e o compartilhamento, desde que sejam atribuídos créditos aos autores, e sem a possibilidade de alterá-la de nenhuma forma ou utilizá-la para fins comerciais.

A responsabilidade pelo conteúdo dos artigos e seus dados, em sua forma, correção e confiabilidade é exclusiva dos autores. A Editora Artemis, em seu compromisso de manter e aperfeiçoar a qualidade e confiabilidade dos trabalhos que publica, conduz a avaliação cega pelos pares de todos manuscritos publicados, com base em critérios de neutralidade e imparcialidade acadêmica.

Editora Chefe	Prof. ^a Dr. ^a Antonella Carvalho de Oliveira
Editora Executiva	M. ^a Viviane Carvalho Mocellin
Direção de Arte	M. ^a Bruna Bejarano
Diagramação	Elisangela Abreu
Organizador	Prof. Dr. Eduardo Eugênio Spers
Imagem da Capa	Shutterstock
Bibliotecário	Maurício Amormino Júnior – CRB6/2422

Conselho Editorial

Prof.^a Dr.^a Ada Esther Portero Ricol, *Universidad Tecnológica de La Habana “José Antonio Echeverría”*, Cuba
Prof. Dr. Adalberto de Paula Paranhos, Universidade Federal de Uberlândia
Prof.^a Dr.^a Amanda Ramalho de Freitas Brito, Universidade Federal da Paraíba
Prof.^a Dr.^a Ana Clara Monteverde, *Universidad de Buenos Aires*, Argentina
Prof.^a Dr.^a Ana Júlia Viamonte, Instituto Superior de Engenharia do Porto (ISEP), Portugal
Prof. Dr. Ángel Mujica Sánchez, *Universidad Nacional del Altiplano*, Peru
Prof.^a Dr.^a Angela Ester Mallmann Centenaro, Universidade do Estado de Mato Grosso
Prof.^a Dr.^a Begoña Blandón González, *Universidad de Sevilla*, Espanha
Prof.^a Dr.^a Carmen Pimentel, Universidade Federal Rural do Rio de Janeiro
Prof.^a Dr.^a Catarina Castro, Universidade Nova de Lisboa, Portugal
Prof.^a Dr.^a Cirila Cervera Delgado, *Universidad de Guanajuato*, México
Prof.^a Dr.^a Cláudia Neves, Universidade Aberta de Portugal
Prof.^a Dr.^a Cláudia Padovesi Fonseca, Universidade de Brasília-DF
Prof. Dr. Cleberton Correia Santos, Universidade Federal da Grande Dourados
Prof. Dr. David García-Martul, *Universidad Rey Juan Carlos de Madrid*, Espanha
Prof.^a Dr.^a Deuzimar Costa Serra, Universidade Estadual do Maranhão
Prof.^a Dr.^a Dina Maria Martins Ferreira, Universidade Estadual do Ceará
Prof.^a Dr.^a Edith Luévano-Hipólito, *Universidad Autónoma de Nuevo León*, México
Prof.^a Dr.^a Eduarda Maria Rocha Teles de Castro Coelho, Universidade de Trás-os-Montes e Alto Douro, Portugal
Prof. Dr. Eduardo Eugênio Spers, Universidade de São Paulo
Prof. Dr. Eloi Martins Senhoras, Universidade Federal de Roraima, Brasil
Prof.^a Dr.^a Elvira Laura Hernández Carballido, *Universidad Autónoma del Estado de Hidalgo*, México



Prof.^ª Dr.^ª Emilas Darlene Carmen Lebus, *Universidad Nacional del Nordeste/ Universidad Tecnológica Nacional, Argentina*
Prof.^ª Dr.^ª Erla Mariela Morales Morgado, *Universidad de Salamanca, Espanha*
Prof. Dr. Ernesto Cristina, *Universidad de la República, Uruguay*
Prof. Dr. Ernesto Ramírez-Briones, *Universidad de Guadalajara, México*
Prof. Dr. Gabriel Díaz Cobos, *Universitat de Barcelona, Espanha*
Prof.^ª Dr.^ª Gabriela Gonçalves, Instituto Superior de Engenharia do Porto (ISEP), Portugal
Prof. Dr. Geoffroy Roger Pointer Malpass, Universidade Federal do Triângulo Mineiro, Brasil
Prof.^ª Dr.^ª Gladys Esther Leoz, *Universidad Nacional de San Luis, Argentina*
Prof.^ª Dr.^ª Glória Beatriz Álvarez, *Universidad de Buenos Aires, Argentina*
Prof. Dr. Gonçalo Poeta Fernandes, Instituto Politécnico da Guarda, Portugal
Prof. Dr. Gustavo Adolfo Juarez, *Universidad Nacional de Catamarca, Argentina*
Prof. Dr. Håkan Karlsson, *University of Gothenburg, Suécia*
Prof.^ª Dr.^ª Iara Lúcia Tescarollo Dias, Universidade São Francisco, Brasil
Prof.^ª Dr.^ª Isabel del Rosario Chiyon Carrasco, *Universidad de Piura, Peru*
Prof.^ª Dr.^ª Isabel Yohena, *Universidad de Buenos Aires, Argentina*
Prof. Dr. Ivan Amaro, Universidade do Estado do Rio de Janeiro, Brasil
Prof. Dr. Iván Ramon Sánchez Soto, *Universidad del Bío-Bío, Chile*
Prof.^ª Dr.^ª Ivânia Maria Carneiro Vieira, Universidade Federal do Amazonas, Brasil
Prof. Me. Javier Antonio Alborno, *University of Miami and Miami Dade College, Estados Unidos*
Prof. Dr. Jesús Montero Martínez, *Universidad de Castilla - La Mancha, Espanha*
Prof. Dr. João Manuel Pereira Ramalho Serrano, Universidade de Évora, Portugal
Prof. Dr. Joaquim Júlio Almeida Júnior, UniFIMES - Centro Universitário de Mineiros, Brasil
Prof. Dr. Jorge Ernesto Bartolucci, *Universidad Nacional Autónoma de México, México*
Prof. Dr. José Cortez Godinez, Universidad Autónoma de Baja California, México
Prof. Dr. Juan Carlos Cancino Diaz, Instituto Politécnico Nacional, México
Prof. Dr. Juan Carlos Mosquera Feijoo, *Universidad Politécnica de Madrid, Espanha*
Prof. Dr. Juan Diego Parra Valencia, *Instituto Tecnológico Metropolitano de Medellín, Colômbia*
Prof. Dr. Juan Manuel Sánchez-Yáñez, *Universidad Michoacana de San Nicolás de Hidalgo, México*
Prof. Dr. Júlio César Ribeiro, Universidade Federal Rural do Rio de Janeiro, Brasil
Prof. Dr. Leinig Antonio Perazolli, Universidade Estadual Paulista (UNESP), Brasil
Prof.^ª Dr.^ª Livia do Carmo, Universidade Federal de Goiás, Brasil
Prof.^ª Dr.^ª Luciane Spanhol Bordignon, Universidade de Passo Fundo, Brasil
Prof. Dr. Luis Fernando González Beltrán, *Universidad Nacional Autónoma de México, México*
Prof. Dr. Luis Vicente Amador Muñoz, *Universidad Pablo de Olavide, Espanha*
Prof.^ª Dr.^ª Macarena Esteban Ibáñez, *Universidad Pablo de Olavide, Espanha*
Prof. Dr. Manuel Ramiro Rodríguez, *Universidad Santiago de Compostela, Espanha*
Prof.^ª Dr.^ª Márcia de Souza Luz Freitas, Universidade Federal de Itajubá, Brasil
Prof. Dr. Marcos Augusto de Lima Nobre, Universidade Estadual Paulista (UNESP), Brasil
Prof. Dr. Marcos Vinicius Meiado, Universidade Federal de Sergipe, Brasil
Prof.^ª Dr.^ª Mar Garrido Román, *Universidad de Granada, Espanha*
Prof.^ª Dr.^ª Margarida Márcia Fernandes Lima, Universidade Federal de Ouro Preto, Brasil
Prof.^ª Dr.^ª Maria Aparecida José de Oliveira, Universidade Federal da Bahia, Brasil
Prof.^ª Dr.^ª Maria Carmen Pastor, *Universitat Jaume I, Espanha*
Prof.^ª Dr.^ª Maria do Céu Caetano, Universidade Nova de Lisboa, Portugal
Prof.^ª Dr.^ª Maria do Socorro Saraiva Pinheiro, Universidade Federal do Maranhão, Brasil
Prof.^ª Dr.^ª Maria Lúcia Pato, Instituto Politécnico de Viseu, Portugal



Prof.^ª Dr.^ª Maritza González Moreno, *Universidad Tecnológica de La Habana*, Cuba
Prof.^ª Dr.^ª Mauriceia Silva de Paula Vieira, Universidade Federal de Lavras, Brasil
Prof.^ª Dr.^ª Ninfa María Rosas-García, Centro de Biotecnología Genómica-Instituto Politécnico Nacional, México
Prof.^ª Dr.^ª Odara Horta Boscolo, Universidade Federal Fluminense, Brasil
Prof. Dr. Osbaldo Turpo-Gebera, *Universidad Nacional de San Agustín de Arequipa*, Peru
Prof.^ª Dr.^ª Patrícia Vasconcelos Almeida, Universidade Federal de Lavras, Brasil
Prof.^ª Dr.^ª Paula Arcoverde Cavalcanti, Universidade do Estado da Bahia, Brasil
Prof. Dr. Rodrigo Marques de Almeida Guerra, Universidade Federal do Pará, Brasil
Prof. Dr. Saulo Cerqueira de Aguiar Soares, Universidade Federal do Piauí, Brasil
Prof. Dr. Sergio Bitencourt Araújo Barros, Universidade Federal do Piauí, Brasil
Prof. Dr. Sérgio Luiz do Amaral Moretti, Universidade Federal de Uberlândia, Brasil
Prof.^ª Dr.^ª Sílvia Inés del Valle Navarro, *Universidad Nacional de Catamarca*, Argentina
Prof.^ª Dr.^ª Solange Kazumi Sakata, Instituto de Pesquisas Energéticas e Nucleares. Universidade de São Paulo (USP), Brasil
Prof.^ª Dr.^ª Stanislava Kashtanova, *Saint Petersburg State University*, Russia
Prof.^ª Dr.^ª Teresa Cardoso, Universidade Aberta de Portugal
Prof.^ª Dr.^ª Teresa Monteiro Seixas, Universidade do Porto, Portugal
Prof. Dr. Valter Machado da Fonseca, Universidade Federal de Viçosa, Brasil
Prof.^ª Dr.^ª Vanessa Bordin Viera, Universidade Federal de Campina Grande, Brasil
Prof.^ª Dr.^ª Vera Lúcia Vasilévski dos Santos Araújo, Universidade Tecnológica Federal do Paraná, Brasil
Prof. Dr. Wilson Noé Garcés Aguilar, *Corporación Universitaria Autónoma del Cauca*, Colômbia
Prof. Dr. Xosé Somoza Medina, *Universidad de León*, Espanha

**Dados Internacionais de Catalogação na Publicação (CIP)
(eDOC BRASIL, Belo Horizonte/MG)**

A277 Agrárias [livro eletrônico] : pesquisa e inovação nas ciências que alimentam o mundo IX / Organizador Eduardo Eugênio Spers. – Curitiba, PR: Artemis, 2023.

Formato: PDF

Requisitos de sistema: Adobe Acrobat Reader

Modo de acesso: World Wide Web

Inclui bibliografia

Edição bilíngue

ISBN 978-65-87396-79-8

DOI 10.37572/EdArt_260223798

1. Ciências agrárias – Pesquisa. 2. Agronegócio. 3. Sustentabilidade. I. Spers, Eduardo Eugênio.

CDD 630

Elaborado por Maurício Amormino Júnior – CRB6/2422



APRESENTAÇÃO

As Ciências Agrárias são um campo de estudo multidisciplinar por excelência, e um dos mais profícuos em termos de pesquisas e aprimoramento técnico. A demanda mundial por alimentos e a crescente degradação ambiental impulsionam a busca constante por soluções sustentáveis de produção e por medidas visando à preservação e recuperação dos recursos naturais.

A obra **Agrárias: Pesquisa e Inovação nas Ciências que Alimentam o Mundo** compila pesquisas atuais e extremamente relevantes, apresentadas em linguagem científica de fácil entendimento. Na coletânea, o leitor encontrará textos que tratam dos sistemas produtivos em seus diversos aspectos, além de estudos que exploram diferentes perspectivas ou abordagens sobre a planta, o meio ambiente, o animal, o homem e a sociedade no ambiente rural.

É uma obra que fornece dados, informações e resultados de pesquisas tanto para pesquisadores e atuantes nas diversas áreas das Ciências Agrárias, como para o leitor que tenha a curiosidade de entender e expandir seus conhecimentos.

Este Volume IX traz 16 trabalhos de estudiosos de diversos países, divididos em dois eixos temáticos: *Eficiência e tecnologia na produção agrícola* e *Meio ambiente e produtividade agrícola*.

Desejo a todos uma proveitosa leitura!

Eduardo Eugênio Spers

SUMÁRIO

EFICIÊNCIA E TECNOLOGIA NA PRODUÇÃO AGRÍCOLA

CAPÍTULO 1..... 1

USO EFICIENTE DA ÁGUA DE REGA EM OLIVAIAS DE ELEVADA DENSIDADE: UMA VISÃO GERAL

Alexandra Tomaz

Justino Sobreiro

Manuel Patanita

Maria Isabel Patanita

 https://doi.org/10.37572/EdArt_2602237981

CAPÍTULO 2..... 13

LOGICIELS POUR LA GESTION DE PLANTATIONS FORESTIÈRES

Edilson Batista de Oliveira

 https://doi.org/10.37572/EdArt_2602237982

CAPÍTULO 3..... 42

DEVELOPMENT AND TEST OF A LOW-COST TUNNEL SPRAYER FOR VINEYARDS

Antonio Odair Santos

Cláudio Alves Moreira

Antônio Carlos Loureiro Lino

 https://doi.org/10.37572/EdArt_2602237983

CAPÍTULO 4..... 57

CARACTERÍSTICAS PRODUCTIVAS Y SOCIOECONÓMICAS DE LA PRODUCCIÓN DE MAÍZ EN UNIDADES DE PRODUCCIÓN FAMILIAR DE OAXACA, MÉXICO

Rafael Rodríguez Hernández

Pedro Cadena Iñiguez

 https://doi.org/10.37572/EdArt_2602237984

CAPÍTULO 5..... 69

EFEECTO DEL AGROPLASMA EN EL CRECIMIENTO Y RENDIMIENTO DE LA KIWICHA, *AMARANTHUS CAUDATUS* VAR. OSCAR BLANCO

Roger Veneros-Terrones

Claudia Díaz-Fernández

Lisi Cerna-Rebaza

Luis Felipe Gonzales-Llontop

Vito Quilcat-León

Julio Chico- Ruiz

 https://doi.org/10.37572/EdArt_2602237985

CAPÍTULO 6..... 84

ESTUDIO DE INFECCIÓN DE *CALIGUS ROGERCRESSEYI* EN SALMÓNIDOS DE CULTIVO POR MEDIO DE TÉCNICAS DE MACHINE LEARNING

Patricio R. de los Ríos-Escalante

Juan Barile

Eriko Carreño

 https://doi.org/10.37572/EdArt_2602237986

CAPÍTULO 7 93

DESARROLLO DE UN LENGUAJE DE INTERCOMUNICACIÓN PARA LA INTEGRACIÓN COLABORATIVA ENTRE DISPOSITIVOS HARDWARE HETEROGÉNEOS Y COMPONENTES SOFTWARE EN EL DOMINIO DE LA GANADERÍA DE PRECISIÓN EN MONOGÁSTRICOS

Vicente López Sacanell

Jesús Pomar Gomá

 https://doi.org/10.37572/EdArt_2602237987

MEIO AMBIENTE E PRODUTIVIDADE AGRÍCOLA

CAPÍTULO 8..... 101

DESARROLLO DE UN MÉTODO CROMATOGRÁFICO COMO ENSAYO DE IDENTIDAD PARA EL CONTROL DE CALIDAD DE UN REMEDIO HERBOLARIO

Guadalupe Yáñez Ibarra

Gabriela Victoria Ruiz Castillo

Ana María Hanan Alipi

Roberto Hernández Villarreal

Gabriela Ávila Villarreal

 https://doi.org/10.37572/EdArt_2602237988

CAPÍTULO 9.....112

PRESENCIA DEL SUGARCANE YELLOW LEAF VIRUS EN *Saccharum* SPP. EN MÉXICO Y FILOGENIA DE UN AISLADO DE COLIMA

Manuel de Jesús Bermúdez Guzmán

María Inés Barbosa Villa

Karina de la Paz García Mariscal

Claudia Yared Michel López

 https://doi.org/10.37572/EdArt_2602237989

CAPÍTULO 10..... 127

CHARACTERIZATION OF PHENOLOGICAL STAGES AND GRAPE QUALITY OF NINETEEN PORTUGUESE GRAPEVINE VARIETIES PRESENT IN THE DOURO REGION

Ivo Fartouce

Joana Amaral Pinto

Paula Cristina Oliveira

Elza Amaral

Rosa Matias

João Paulo Moura

Aureliano Malheiro

Ana Alexandra Oliveira

 https://doi.org/10.37572/EdArt_26022379810

CAPÍTULO 11..... 146

INFLUENCIA DE LAS BRISAS DE TIERRA Y MAR SOBRE EL MICROCLIMA DE LA CANOPIA

Gerardo Echeverría Grotiuz

Nicolás Demetriuk

 https://doi.org/10.37572/EdArt_26022379811

CAPÍTULO 12 161

CAPTURA DE CARBONO EN EL SUELO CON PRÁCTICAS DE MANEJO AGRONÓMICO EN MAÍZ PARA GRANO DE TEMPORAL

Hugo Ernesto Flores-López





Gloria Vidrio-Llamas

Irma Julieta González-Acuña

Celia de la Mora-Orozco

Humberto Ramírez-Vega

 https://doi.org/10.37572/EdArt_26022379812

CAPÍTULO 13	169
RECURSOS GENÉTICOS DEL MAÍZ DESPOJO Y RESISTENCIA	
Yolanda Cristina Massieu Trigo	
 https://doi.org/10.37572/EdArt_26022379813	
CAPÍTULO 14	179
INSUMOS AGROECOLÓGICOS PARA MANEJO DEL AMARILLAMIENTO EN NARANJA VALENCIA TARDÍA (<i>Citrus sinensis</i> L. Osbeck) EN VERACRUZ, MÉXICO	
Manuel Ángel Gómez Cruz	
Laura Gómez Tovar	
María de los Ángeles Hernández-Andrade	
Asunción Gálvez-Mendoza	
Luis Enrique Ortiz-Martínez	
 https://doi.org/10.37572/EdArt_26022379814	
CAPÍTULO 15	185
ANTIOXIDANTES <i>IN VITRO</i> : EFECTOS SOBRE VIABILIDAD ESPERMÁTICA EN TRUCHA ARCOÍRIS (<i>Oncorhynchus mykiss</i> , Walbaum, 1792)	
Eliana Ibáñez-Arancibia	
Iván Valdebenito Isler	
Jorge G. Farías	
 https://doi.org/10.37572/EdArt_26022379815	
CAPÍTULO 16	196
USE OF A PCR-RFLP MOLECULAR TEST FOR THE DIFFERENTIATION OF <i>Babesia bovis</i> AND <i>Babesia bigemina</i> IN THE DIAGNOSIS OF BOVINE BABESIOSIS	
José Juan Lira Amaya	
Diego Jesús Polanco Martínez	
Rebeca Montserrat Santamaría Espinosa	
Grecia Martínez García	
Carmen Rojas Martínez	
Jesús Antonio Álvarez Martínez	
Julio Vicente Figueroa Millán	
 https://doi.org/10.37572/EdArt_26022379816	
SOBRE O ORGANIZADOR	208
ÍNDICE REMISSIVO	209

CAPÍTULO 10

CHARACTERIZATION OF PHENOLOGICAL STAGES AND GRAPE QUALITY OF NINETEEN PORTUGUESE GRAPEVINE VARIETIES PRESENT IN THE DOURO REGION

Data de submissão: 03/01/2023

Data de aceite: 20/01/2023

Rosa Matias⁵

Polytechnic Institute of Leiria
Leiria, Portugal

Ivo Fartouce¹

Research fellow of
INNOVINE&WINE project
University of Trás-os-Montes and
Alto Douro
Vila Real, Portugal

<https://orcid.org/0000-0001-5220-9314>

João Paulo Moura^{2,3}

University of Trás-os-Montes and
Alto Douro
Vila Real, Portugal

Aureliano Malheiro^{1,2}

University of Trás-os-Montes and
Alto Douro
Vila Real, Portugal

Joana Amaral Pinto¹

Research fellow of
INNOVINE&WINE project
University of Trás-os-Montes and
Alto Douro
Vila Real, Portugal

Ana Alexandra Oliveira^{1,2}

University of Trás-os-Montes and
Alto Douro
Vila Real, Portugal

Paula Cristina Oliveira^{2,3}

University of Trás-os-Montes and
Alto Douro
Vila Real, Portugal

Elza Amaral⁴

University of Trás-os-Montes and
Alto Douro
Vila Real, Portugal

ABSTRACT: The present work aimed to evaluate the most suitable grapevine varieties in a specific site of the Douro Region, along two consecutive years characterized by different weather conditions. It was analyzed the mesoclimate in which the grapevine varieties were inserted through bioclimatic indexes. It was determined the Growing Degree Days (GDD) necessary for the occurrence and duration of following periods: from budburst to flowering; flowering; from flowering to veraison; veraison; and from veraison to harvest. For each grapevine variety, the variation of the

¹ Department of Agronomy, School of Agrarian and Veterinary Sciences, University of Trás-os-Montes and Alto Douro, 5000-801 Vila Real, Portugal.

² Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB), University of Trás-os-Montes and Alto Douro, 5000-801 Vila Real, Portugal.

³ Engineering department, School of Science and Technology, University of Trás-os-Montes and Alto Douro, 5000-801 Vila Real, Portugal.

⁴ Centre of Mathematics (CMAT-UTAD) 5000-801 Vila Real, Portugal.

⁵ Computer Science and Communication Research Centre (CIIC), DEI ESTG, Polytechnic Institute of Leiria, 2411-901 Leiria, Portugal.

Growing Degree Days in different periods was evaluated and classified as low, medium and high. Grape quality was assessed by the total soluble solids, the total polyphenols, the tannins and the total anthocyanins. The results explored differences between grapevine varieties on the Growing Degree Days along the growing season and also on the grape quality. Grapevine varieties with longer growing seasons, high GDD from veraison to harvest and a progressive maturation may be better adapted to the warming scenarios. Aragonez, Roseira, Tinta Carvalha, Tinta Francisca, Touriga Franca and Touriga Fêmea showed high GDD from veraison to harvest, which highlight their better adaptation to the warmer months, based on observed weather conditions of studied years. Roseira and Tinta Francisca presented the most balanced grape quality parameters, revealing to be suitable minor grapevine varieties in this specific site of the Douro Region, exposed to different weather conditions.

KEYWORDS: Minor grapevine varieties. Bioclimatic indexes. Growing Degree Days. Maturation.

CARACTERIZAÇÃO DOS ESTADOS FENOLÓGICOS E DA QUALIDADE DA UVA DE DEZANOVE CASTAS PORTUGUESAS PRESENTES NA REGIÃO DO DOURO

RESUMO: Este trabalho teve como objetivo avaliar as castas de videira mais adequadas num local específico da Região Demarcada do Douro, ao longo de dois anos consecutivos caracterizados por condições climáticas distintas. Foi analisado o mesoclima em que as castas estavam inseridas através de índices bioclimáticos. Foram determinados os Graus-Dia de crescimento (GDD) necessários para a ocorrência e a duração dos seguintes períodos: do abrolhamento à floração; floração; da floração ao pintor; pintor; e do pintor à vindima. Para cada casta avaliou-se a variação dos GDD em diferentes períodos e classificou-se em baixo, médio e alto. A qualidade da uva foi avaliada pelos sólidos solúveis totais, polifenóis totais, taninos e antocianinas totais. Os resultados exploraram diferenças entre castas nos GDD ao longo do ciclo vegetativo e também na qualidade da uva. As castas com períodos de crescimento mais longos, GDD mais elevados desde o pintor até à vindima e uma maturação progressiva podem adaptar-se melhor a cenários de aquecimento. Aragonez, Roseira, Tinta Carvalha, Tinta Francisca, Touriga Franca e Touriga Fêmea apresentaram GDD elevados desde o pintor até à vindima, o que destaca a sua melhor adaptação aos meses mais quentes, com base nas condições climáticas observadas nos anos estudados. Roseira e Tinta Francisca apresentaram os parâmetros de qualidade da uva mais equilibrados, revelando serem castas minoritárias aptas para este local específico da Região Demarcada do Douro, expostas a diferentes condições climáticas.

PALAVRAS-CHAVE: Castas minoritárias. Índices bioclimáticos. Graus-dia de crescimento. Maturação.

1 INTRODUCTION

Climate variability influences wine grape production, particularly in the Mediterranean region as the Douro Region, Portugal (Dinis *et al.*, 2014). However, global and regional model simulations to Portugal project a scenario of warming, increase of near surface temperature and dramatic changes of all temperature related climate indices.

Impacts are higher in summer and autumn and in the interior of the country (Miranda et al., 2002). Each site has its specific weather conditions which influence the type of wine that can be produced. The specificity of each site is called *terroir*, that is interaction between many factors, including climate, soil, variety and human practices (Van Leeuwen and Seguin, 2006; Van Leeuwen et al. 2004). The maturation time of variety must be adequate to each site weather conditions in such a way that full maturation is reached by the end of the growing season (Van Leeuwen and Seguin, 2006). Within the weather conditions, the temperature have a high importance in the growing season, grapevine yield and grape quality (Barnuud et al., 2014; Malheiro et al., 2013; Santos et al., 2013; Jones, 2012). Timing and duration of each phenological stage are influenced by air temperature and depends on grapevine varieties. The relation between temperature and phenological stages has been supported by several studies (Ramos et al. 2018; Ramos, 2017; Fraga et al., 2016; Fraga et al., 2015; Neumann et al., 2014; Lopes et al., 2008). The monthly maximum temperature that anticipates phenological stages, such as budburst and flowering, have a great influence at the date these events occur (Tomasi et al., 2011). Fraga (2014a) indicated that the Growing Degree Days (GDD) throughout the growing season allow us to identify which varieties are better adapted to a given site and to define which more resistant to long periods of high temperatures. Therefore, varieties with low GDD have more adaptive difficulty to prolonged temperature increases over time. The same author described that varieties such as Touriga Franca and Tinto Cão would better adapt to a temperature increases, while varieties such as Vinhão will have less adaptability (Fraga, 2014a). The grapevine genetic regulation mechanisms, such as gene production and the adaptation mechanisms, such as self-regulation (Fraga et al., 2012; Brito et al., 2004) allows a high resistance to water and thermal stresses (Saleh et al., 2018). Bioclimatic indexes can be used to assess whether the site is suitable for a good grapevine production (Barnuud et al., 2014; Santos et al., 2013; Jones, 2012; Malheiro et al., 2010). The GDD is related to grapevines growth and development, wine production and its quality (Fraga et al., 2016; Neumann et al., 2014). Considering base temperature at 10 °C, GDD values were pointed out for the growing season in the Douro Region, ranges from 1776 to 2241 (Magalhães et al., 1995) and has estimated an increase of 600 by 2070 (Fraga, 2014a). The Huglin Index (HI) is used to evaluate the grapevine thermal needs to complete its phenological stages until maturation. It relates those needs to the thermal characterization of a given site, determining whether it meets the thermal needs of a particular grapevine variety (Jones et al., 2005; Huglin, 1978). Santos et al. (2012) defined a minimum vegetative growth limit of 850 for GDD and 900 for HI. Lacona et al. (2012) verified that anthocyanins concentration decreased when GDD and HI increased, while

tannins concentration increased when GDD and HI increased. The Hydrothermal Index of Branas (IBBL) combines the humidity effect (through precipitation) and temperature during the growing season to evaluate the susceptibility risk for diseases, such as downy mildew (Branas *et al.*, 1946). Lorenzo *et al.* (2012) registered HI values until 2200 and above 2000 for IBBL in Galiza (North of Spain). Same authors verified that when IBBL increased, production and quality decreased. They projected to future scenario a tendency to the increase of GDD and HI as well as the decrease of IBBL (Lorenzo *et al.*, 2012). The Cold night Index (CI) relates to the night minimum temperatures during the last month of maturation stage (Tonietto *et al.*, 2004). Fraga (2014a) reported an increase of night temperatures during the last month of maturation (usually in September), where monthly minimum temperatures can reach to 16 °C by 2070 in Douro Region. During the night, the optimal temperatures for maturation can be reached, having a significant effect in the anthocyanins' synthesis (Kliewer and Torres cited by Martínez de Toda, 2011). The optimal temperature for anthocyanins' synthesis ranges from 17 to 26 °C (Pirie cited Martínez de Toda, 2011; Sadras *et al.*, 2007). Temperatures above 30 °C can damage biosynthetic pathways, promoting the degradation of anthocyanins' components which decreases its concentration (Mori *et al.*, 2007). Temperatures above 35 °C inhibit the anthocyanin synthesis (Magalhães, 2008; Mori *et al.*, 2007; Lopes, 1994). Greer (2017) determined a maximum limit of 30 °C to biomass accumulation in bunches for Semillon grapevine variety. Several countries are currently recovering and characterizing autochthonous varieties, nearly extinct in some cases, as potential producers of quality wines (Loureiro *et al.*, 2017; Milella *et al.*, 2016; Dobrei *et al.*, 2015; Merkouropoulos *et al.*, 2015). For example, Loureiro *et al.* (2017) referred that the prospection, recovery and study of minor grapevine varieties are important to preserve the genetic resources of a region. Additionally, the authors considered that the conservation of the existing varieties can allow to face the new challenges for the viticulture such as future warming scenarios (Loureiro *et al.*, 2017). The present work aimed to evaluate the most suitable grapevine varieties in a specific site of the Douro Region, along two consecutive years characterized by different weather conditions. The GDD needed to reach some growing season periods of 19 grapevine varieties was assessed and related to the grape quality. The vineyard mesoclimate was analysed by several bioclimatic indexes. The GDD values were calculated for the following periods: from budburst to flowering; flowering; from flowering to veraison; veraison; and from veraison to harvest. The variation of GDD in the different growing season periods was evaluated for each grapevine variety and were classified as low, medium and high. The grape quality was measured as total soluble solids, total polyphenols, tannins, and total anthocyanins.

2 MATERIAL AND METHODS

2.1 DESCRIPTION OF THE STUDY SITE AND THE PLANT MATERIAL

Data were collected on a vineyard with a grapevine collection located in Pinhão (41°10'26.28"N, 7°31'47.03"W; 375 m) at Cima-Corgo, Douro Region (Northern Portugal) during two consecutive years (2017 and 2018). The vineyard is exposed to the north (northeast direction). The soil was characterized by silty-loam, low organic matter content (below 1%) and acid pH. The temperature and precipitation values were monitored by an automatic weather station (IMT280, iMETOS, Weiz, Austria) located near the vineyard (41°10'47.36"N, 7°32'05.79"W; 230m). The vineyard was systematized by traditional terraces and grafted in 1940 on *Rupestris du Lot* rootstock. The grapevines, spaced 1 m within and 1.20 m between rows, were pruned to a short 2-bud spurs. The data were obtained from 56 selected grapevines, where 19 red varieties (*Vitis vinifera*) were identified by SSR (simple sequence repeat) markers: Aragonez, Camarate, Casculho, Castelão, Cornifesto, Malvasia Preta, Marufo, Mourisco de Semente, Nevoeira, Roseira, Tinta Carvalha, Tinta da Barca, Tinta Francisca, Tinto Cão, Touriga Fêmea, Touriga Franca, Touriga Nacional, Trincadeira and Vinhão. According to IVV ranking of varieties most planted in Portugal (IVV, 2018), Camarate, Casculho, Cornifesto, Malvasia Preta, Mourisco de Semente, Nevoeira, Roseira, Tinta Carvalha, Tinta da Barca, Tinta Francisca and Touriga Fêmea were considered minor grapevine varieties, since they are not included in the first 20 ranking positions. According to Eiras-Dias *et al.* (2016), minor grapevine varieties are those that were not planted over a long period and consequently are mainly present old vineyards.

2.2 EXPERIMENTAL DESIGN

The experimental design was composed by 56 grapevines selected in vineyard through different ampelographic characteristics and subjected to genetic identification. These 56 grapevines were selected based on the potential of production and quality described by the farmer. The study identified 19 grapevine varieties. All determinations were performed to the 56 grapevines (3 grapevines per variety) and data were treated for each grapevine. The samples to analyse the grape quality had 10 random berries per grapevine. All grapevine varieties were subjected to the same weather and soil conditions. Grapevines were managed without irrigation. Cultural practices and phytosanitary treatments were the same to all grapevines.

2.3 PHENOLOGICAL PERIODS ANALYSED AND BIOCLIMATIC INDEXES CALCULATED

The phenological stages of each grapevine from budburst to harvest were monitored and determined by the visual observation using the Baggiolini scale. Five periods of the growing season were considered: from budburst to flowering (B-I); flowering (I); from flowering to veraison (I-M); veraison (M); and from veraison to harvest. Considering vegetative zero at 10 °C, calculations of bioclimatic indexes (Table 1) were performed through minimum, mean and maximum temperatures; precipitation and insolation (INMG, 1988).

Table 1. Bioclimatic indexes used for the weather characterization.

GDD (Winkler, 1974)	HI (Huglin, 1978)
$GDD = \sum_{1apr}^{30set} (T - 10)$ <p>T: daily mean temperature (°C).</p>	$HI = \sum_{1apr}^{30set} \left[\frac{(T - 10) + (T_{max} - 10)}{2} \right] K$ <p>T: daily mean temperature (°C); Tmax: daily maximum temperature (°C); K: coefficient of 40° latitude.</p>
IBBL (Branas <i>et al.</i> , 1946)	CI (Tonietto <i>et al.</i> , 2004)
$IBBL = \sum_{apr}^{set} P T_m$ <p>P: monthly precipitation (mm); Tm: monthly mean temperature (°C).</p>	<p>CI = Tmin of last month of maturation Tmin: monthly minimum temperature (°C).</p>
Other indexes used	
HTC (Selianinov, 1928)	LTI (Kenny and Shao, 1992)
$HTC = \left[\sum_{apr}^{set} P / X \right] 10$ <p>P: monthly precipitation (mm); X: sum of Winkler (°C).</p>	<p>LTI = MTWM (75 – latitude) MTWM: daily mean temperature of the hottest month (°C); 40° latitude.</p>
PH (Branas <i>et al.</i> , 1946)	
$PH = X H 10^{-6}$ <p>X: sum of Winkler (°C); H: sum of monthly insolation (hours).</p>	

GDD - Growing Degree Days, index of the sum of Winkler active temperatures, **HI** - Heliothermic Index of Huglin; **IBBL** - Branas Hydrothermal Index; **CI** - Cold night Index; **HTC** - Selianinov Hydrothermal Coefficient; **LTI** - Latitude-Temperature Index; **PH** - Heliothermic Product of Branas.

For the five periods considered, the GDD values of each variety were calculated. After that, three equal intervals between the maximum and minimum GDD were used to classify the varieties about GDD required for each period in the two years. These intervals were presented in Table 2.

Table 2. Intervals used by collected data to classify the varieties according to the GDD required in the five periods within the growing season. Values presented (in degree-days) were obtained by average of the two studied years.

	B - F	F	F - V	V	V - H
Interval	294 - 368	83 - 163	765 - 996	183 -392	499 - 747
Low	<319	<110	<842	<253	<582
Medium	319≤ GDD ≤344	110≤ GDD ≤136	842≤ GDD ≤919	253≤ GDD ≤323	582≤ GDD ≤664
High	>344	>136	>919	>323	>664

B - F: from budburst to flowering; **F**: flowering; **F - V**: from flowering to veraison; **V**: veraison; **V - H**: from veraison to harvest.

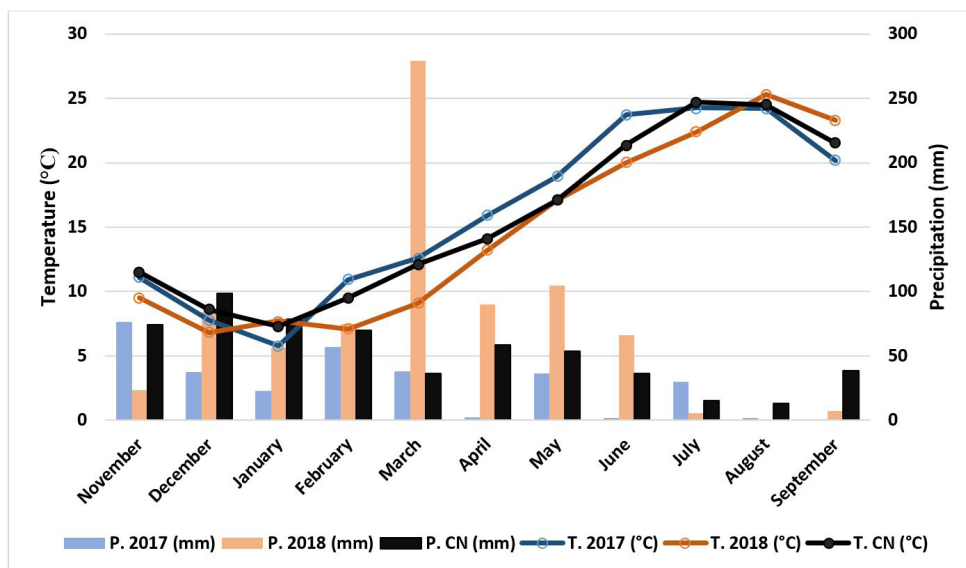
2.4 GRAPE QUALITY

The grape quality was assessed by the total soluble solids on the homogenate pulp, while the total polyphenols, the tannins and the total anthocyanins were measured in the seeds and skins, following OIV methods (2006). Total polyphenols and tannins values are expressed in mg of epicatechin per gram of berry and total anthocyanins values are expressed in mg of malvidine-3-glucoside per gram of berry. Results are showed as average values of the two years ± standard deviation. The quality parameters were compared for each grapevine variety, applying a linear projection represented by the radial visualization (RadViz) (Matias, 2017; Rubio-Sánchez *et al.*, 2015).

3 RESULTS AND DISCUSSION

The old vineyards in the Douro Region are characterized by the high diversity of varieties and its heterogeneous distribution. Thus, a study focusing on the old vineyards in the Douro can be limited by the not exist single-varietal vineyards on the same soil-climatic conditions. Furthermore, the number of vineyards with the same age, diversity of varieties and soil-climatic conditions in the Douro Region is scarce. Therefore, and although in this study the number of grapevines per variety can be considered insufficient, this reflects the old vineyards' composition in the Douro region. Concerning the weather conditions of studied site presented in Figure 1, 2017 and 2018 presented differences in the monthly temperature and precipitation values. Along the growing season, 2017 was warmer and drier than 2018, with the exception of August and September temperatures.

Figure 1 - Temperature and precipitation values for 2017 and 2018. CN: Climatological normal "1971-2000".



The growing season average temperature of 2017 was 21.2 °C, while in 2018 was 20.2 °C. These average temperatures were higher than those indicated by Jones (2013) for Cima-Corgo (Douro Region). Precipitation values from April to September, were 72.6 mm for 2017 and 274.2 mm for 2018. Comparing these with the Climatological Normal "1971-2000" that registered 20.6 °C and 215.8 mm, these two consecutive years demonstrated the different weather conditions existing in the Douro Region. The phenological stages in 2017 were two or three weeks earlier than 2018, which could be explained by the higher temperature values registered in 2017. From the beginning of veraison to harvest, were observed seventeen days above 35 °C in 2017 and twelve days in 2018. According to the bioclimatic indexes presented in Table 3, the grapevines from the two years were exposed to similar warmer conditions and different water circumstances.

Table 3. Bioclimatic indexes calculated for the weather characterization.

Bioclimatic Index	2017	2018	Value ranges	Classification
GDD	2055	1881	1850 < GDD < 2120	Hot
HI	2821	2571	2400 < HI < 3000	Warm
IBBL	1545	4608	IBBL < 3000; GDD > 1550	Exceptional quality
			4000 < IBBL < 5000; GDD > 1550	Good quality

Bioclimatic Index	2017	2018	Value ranges	Classification
CI	16.6	16.3	14 < CI < 18 °C	Temperate nights
HTC	0.35	1.46	HTC < 0.4	Extreme drought
			HTC > 1	No drought
LTI	849	886	LTI > 700	Hot climate grape
PH	3.2	2.9	PH > 2,6	Production viable zone

GDD - Growing degree-days, index of the sum of Winkler active temperatures, **HI** - Heliothermic Index of Huglin; **IBBL** - Branas Hydrothermal Index; **CI** - Cold night Index; **HTC** - Seliyaninov Hydrothermal Coefficient; **LTI** - Latitude-Temperature Index; **PH** - Heliothermic Product of Branas.

The GDD values of vineyard were within those presented by Magalhães *et al.* (1995) for the Douro Region and more specifically within the values for the Cima-Corgo indicated by Jones (2013). The HI showed higher values those presented by Jones (2013) for Cima-Corgo, caused by the higher temperatures registered in the studied years. The CI exhibited above 16 °C to monthly minimum temperature what reached the conditions predicted for 2070 in the Douro Region pointed out by Fraga (2014a). The HTC values corroborate the dryness in 2017. Among the two years, comparing HTC with IBBL on grape quality, it was evident the influence of the different weather conditions on grapevine varieties. For the two years, the GDD from budburst to harvest were similar for all varieties, ranging from 1820 (Nevoeira) to 1850 (Malvasia Preta). The GDD values of different periods are presented in Figures 2 and 3. GDD values did not showed a strong relationship between the growing season periods' duration. For example, a short period from budburst to flowering does not imply a short period from flowering to veraison, which was also verified by Tomasi *et al.* (2011). For the majority of grapevine varieties, the period with highest GDD was from flowering to veraison. Ramos (2017) also found that this period had the highest GDD values. Comparing the shorter periods (flowering and veraison), the period with lowest GDD values was the flowering for the majority of grapevines analysed (Figure 3).

Figure 2. Chronological evolution in growing season of the periods: from budburst to flowering; from flowering to veraison; from veraison to harvest with the corresponding GDD. Data are presented for 2017 and 2018.

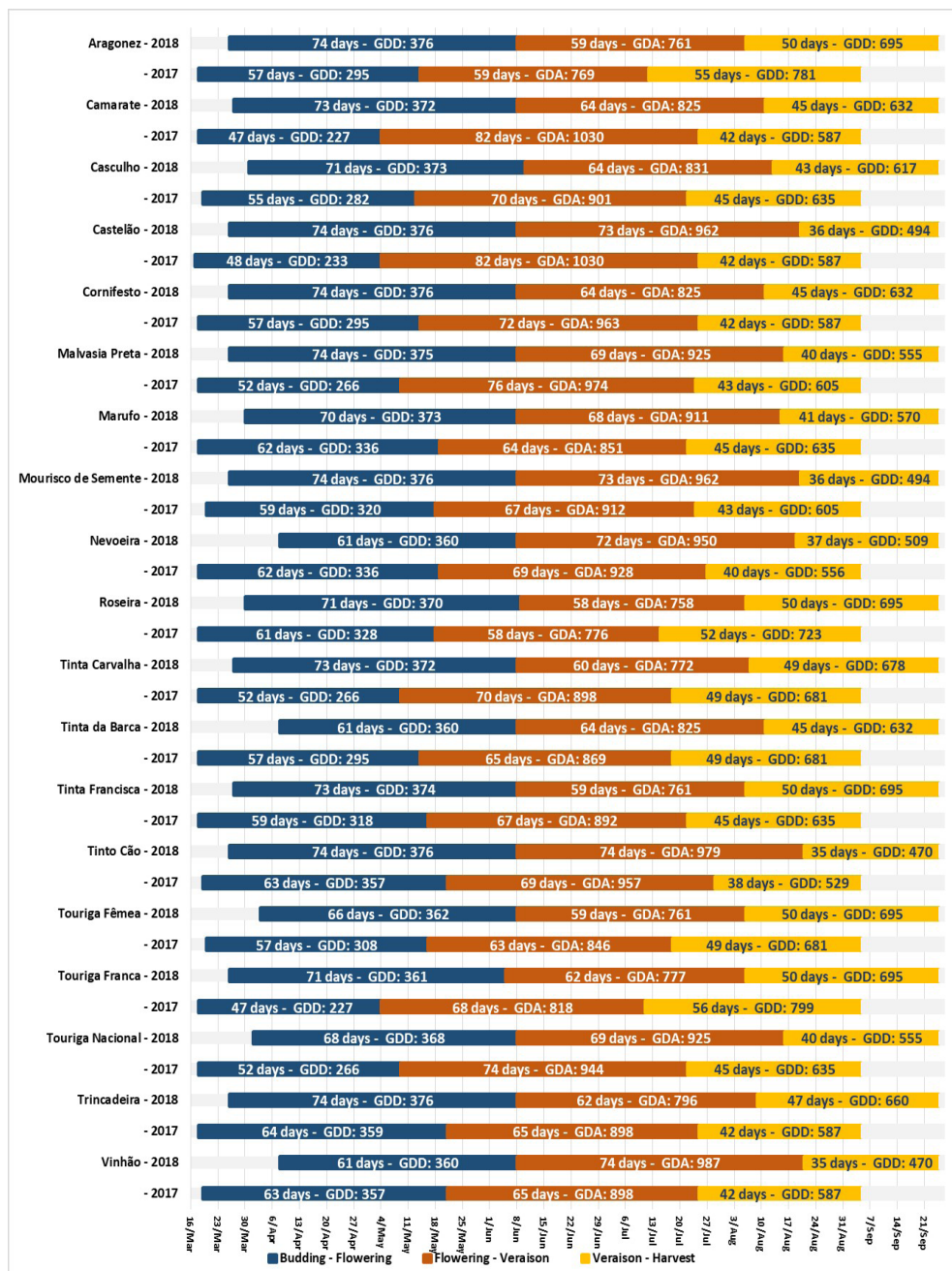
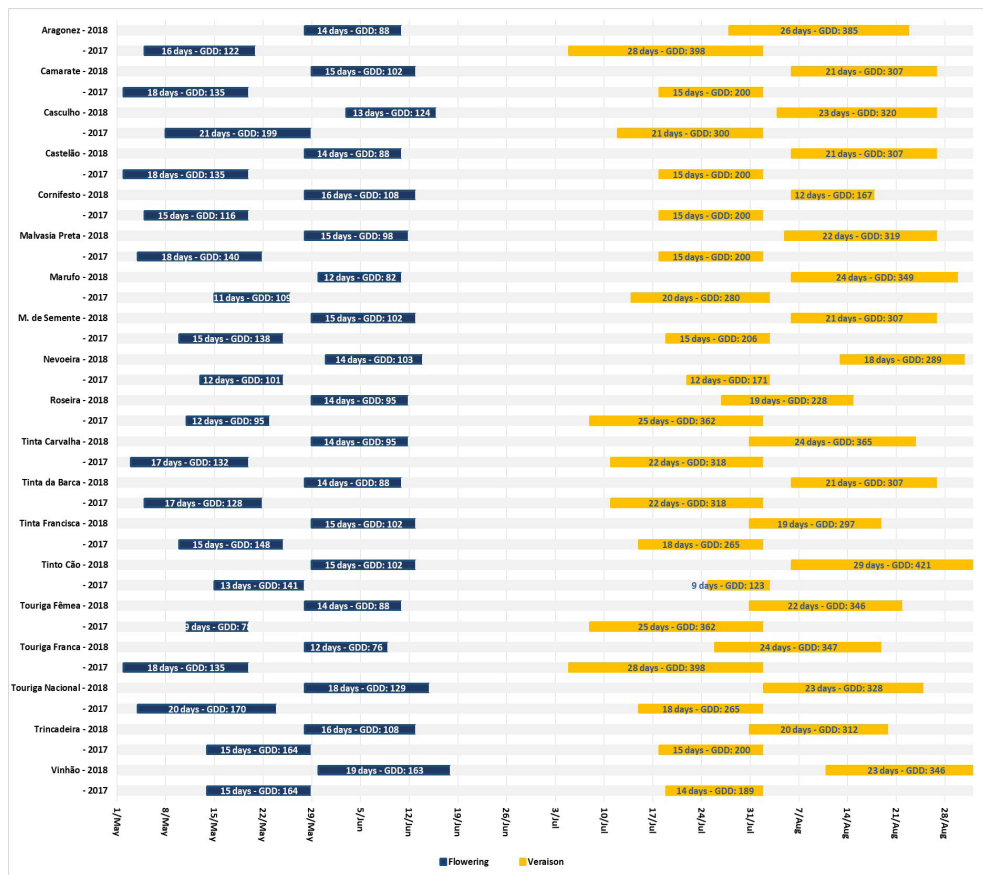


Figure 3. Chronological evolution of flowering and veraison periods with the corresponding GDD. Data are presented for 2017 and 2018.



The classification of the growing season periods were applied to the two years, the results are illustrated in Table 4. According to this classification, Vinhão, Nevoeira or Marufo varieties showed high GDD values in budburst-flowering period and simultaneously, had a later flowering in both years (Figure 2 and 3). Touriga Franca and Castelão showed, at the same time, low GDD values in budburst-flowering period (Table 4) and an early flowering (Figure 2 and 3). During budburst-flowering period, Lopes *et al.* (2008) observed similar results, with Vinhão having a high GDD and Touriga Franca a low GDD. Concerning the duration of flowering, Touriga Nacional exhibited longest flowering in both years.

Table 4. Classification of GDD in the five growing season periods, with ranges of values considered for each period (average of the two studied years).

	B - F	F	F - V	V	V - H
Aragonez	Medium	Low	Low	High	High
Camarate	Low	Medium	High	Medium	Medium
Casculho	Medium	High	Medium	Medium	Medium
Castelão	Low	Medium	High	Medium	Low
Cornifesto	Medium	Medium	Medium	Low	Medium
Malvasia Preta	Medium	Medium	High	Medium	Low
Marufo	High	Low	Medium	Medium	Medium
Mourisco de Semente	High	Medium	High	Medium	Low
Nevoeira	High	Low	High	Low	Low
Roseira	High	Low	Low	Medium	High
Tinta Carvalha	Low	Medium	Low	High	High
Tinta da Barca	Medium	Low	Medium	Medium	Medium
Tinta Francisca	High	Medium	Low	Medium	High
Tinto Cão	High	Medium	High	Medium	Low
Touriga Fêmea	Medium	Low	Low	High	High
Touriga Franca	Low	Low	Low	High	High
Touriga Nacional	Low	High	High	Medium	Medium
Trincadeira	High	Medium	Medium	Medium	Medium
Vinhão	High	High	High	Medium	Low

B - F: from budburst to flowering; **F**: flowering; **F - V**: from flowering to veraison; **V**: veraison; **V - H**: from veraison to harvest.

During flowering-veraison period, Vinhão, and Nevoeira presented, simultaneously, high GDD (Table 4) and later veraison (Figure 2 and 3). On contrary, varieties such as Aragonez, Touriga Franca and Roseira showed a low GDD and an early veraison. For the same period, Lopes *et al.* (2008) mentioned that Aragonez and Touriga Franca had low GDD, considering Touriga Franca as a variety with an earlier veraison. Concerning the duration of veraison in the present study, Aragonez and Touriga Franca exhibited a longer veraison in both years. Although no relationship between the growing season periods could be established, it seems to be relevant that varieties presenting high GDD during veraison (Aragonez, Tinta Carvalha, Touriga Fêmea and Touriga Franca), had low GDD in flowering-veraison period. These varieties did not present high GDD variability between the two years in flowering-veraison and veraison periods, which may mean that these varieties were poorly affected by the different weather conditions in these periods. During the veraison-harvest period, Aragonez, Touriga Franca, Roseira, Tinta Francisca, Touriga

Fêmea and Tinta Carvalha presented high GDD. Similarly, Lopes *et al.* (2008) also showed that Touriga Franca had high GDD during the same period. Varieties as Vinhão, Castelão, Tinto Cão, Malvasia Preta, Nevoeira and Mourisco de Semente demonstrated low GDD in veraison-harvest period. In this period, the varieties that showed the higher GDD variability between the two years were Vinhão, Touriga Franca and Mourisco de Semente. During the warmer months the accumulation of GDD was higher and the future scenarios' projections indicate an increase of temperatures, especially in summer, where the maturation will occur under increasingly warm conditions being likely to accelerate it (Duchene *et al.*, 2005; Miranda *et al.*, 2002). Table 5 shows the quality parameters analysed of all varieties and the variability of the two years, observed by the standard deviation.

Table 5. Quality parameters of 19 grapevine varieties (average of the two studied years).

	TSS (°Brix)	Polyphenols (mg/g)	Tannins (mg/g)	Anthocyanins (mg/g)
Aragonez	24.3±0.6	13.1±2.1	5.2±0.7	1.7±0.3
Camarate	19.1±1.4	10.3±2.2	4.3±0.2	1.0±0.1
Casculho	18.0±0.4	9.3±1.2	4.0±1.0	1.0±0.2
Castelão	22.3±0.6	8.1±1.8	2.2±0.4	1.3±0.3
Cornifesto	20.9±0.4	9.6±2.0	3.6±0.1	1.3±0.3
Malvasia Preta	21.3±1.5	12.6±2.4	4.3±1.6	1.6±0.4
Marufo	24.3±1.0	5.6±0.9	2.0±0.5	0.4±0.0
Mourisco de Semente	19.6±0.3	8.2±1.9	3.7±1.6	0.6±0.2
Nevoeira	18.2±0.2	9.0±1.9	3.9±0.9	0.7±0.2
Roseira	20.6±0.6	10.2±2.6	3.8±0.7	1.2±0.4
Tinta Carvalha	20.6±1.1	8.0±1.1	3.5±1.6	0.6±0.3
Tinta da Barca	19.6±0.1	11.7±0.9	4.2±1.6	1.1±0.1
Tinta Francisca	19.9±0.1	10.5±1.9	3.8±0.8	1.0±0.1
Tinto Cão	21.9±0.3	20.7±2.5	5.0±1.4	1.9±0.5
Touriga Fêmea	24.1±0.5	10.4±2.5	3.5±0.9	1.2±0.3
Touriga Franca	19.4±0.2	14.1±2.0	4.3±1.9	1.6±0.3
Touriga Nacional	21.2±1.7	12.5±2.5	3.9±1.2	1.7±0.4
Trincadeira	21.6±0.0	10.6±3.0	3.3±0.6	1.6±0.1
Vinhão	22.6±1.6	19.1±3.6	5.8±1.3	3.1±0.3

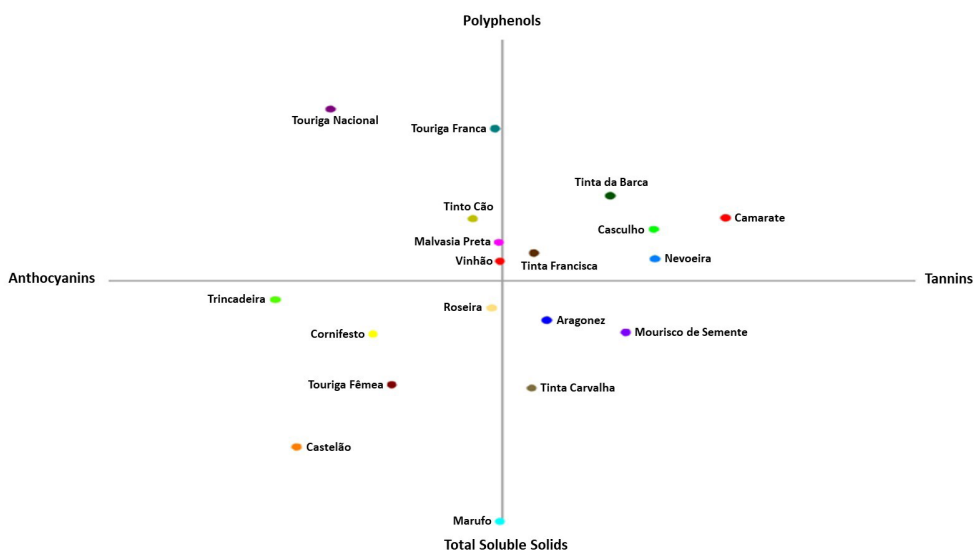
TSS- total soluble solids. **Total polyphenols and tannins**: mg epicatechin / g berry; **total anthocyanins**: mg malvidine /g berry.

Considering the two years, varieties with low GDD during maturation such as Castelão, Malvasia Preta, Tinto Cão and Vinhão showed a fast evolution of quality

parameters such as the total soluble solids. This fast evolution may demonstrate the influence that high temperatures had on these varieties during maturation in these two years. It should be highlighted that Vinhão presented later veraison, as previously described. Vinhão and Tinto Cão showed long growing season periods until veraison, with high GDD. The same occurred with Malvasia Preta, specifically from flowering to veraison. Fraga (2014a) indicated Tinto Cão and Malvasia Preta as varieties with good adaptability to different climatic conditions. The author analysed the same adaptability aspects in several grapevine varieties, concluding that Touriga Franca also presented a good adaptability to different climatic conditions, moreover higher GDD mean values than Tinto Cão and Malvasia Preta (Fraga, 2014a). In the present study, the GDD mean values did not show significant differences between the grapevine varieties, as observed by Fraga (2014a). The values observed in this study indicate close GDD values for all varieties between 2017 and 2018, including Malvasia Preta (1850), Touriga Franca (1838) and Tinto Cão (1833). As previously described, Touriga Franca presented high GDD from veraison to harvest and among the varieties with high GDD in this period, was the variety that exhibited the higher phenolic maturation simultaneously with Aragonez. However, Aragonez presented higher total soluble solids and seems to be at its ideal maturation. According to the quality parameters of 2017 and 2018, defined in this study, the prospect of increasing temperatures in the maturation period may cause higher changes in the Aragonez quality profile, when compared to Touriga Franca. Touriga Franca's quality can still be improved through a longer maturation period, since it exhibited a low value of total soluble solids. Among the varieties with high GDD in veraison-harvest period, Tinta Carvalha had the lower phenolic maturation. Other varieties, such as Marufo and Touriga Fêmea, also presented elevated total soluble solids. However, at the same time, Marufo showed lower phenolic richness and lower GDD from veraison to harvest compared to Touriga Fêmea. Marufo was referred by Fraga et al. (2015) as being a variety with low adaptability in warm regions, as in accordance with the results obtained for the present study. Touriga Fêmea had a phenolic composition similar to Tinta Francisca and Roseira. Tinta Francisca and Roseira showed similar GDD behaviours during the growing season with high GDD in maturation. Furthermore, the balance between total soluble solids and phenolic composition may reveal a good resistance potential to the prospects of warming future scenarios. Comparing the varieties with high GDD in veraison-harvest period, Tinta Francisca presented the lowest quality parameters variability between the two years, according to the standard deviation. Regarding all varieties in study, Marufo demonstrated to be the lowest affected by the different weather conditions between 2017 and 2018.

Camarate, Casculho, Mourisco de Semente, Nevoeira and Tinta da Barca could benefit from a longer maturation period, leading to a complete phenolic maturation, an important advantage to obtain higher quality. Since Mourisco de Semente and Nevoeira also demonstrated a longer growing season until veraison, could be interesting to study their GDD until ideal maturation to evaluate if maturation is progressive. Figure 4 shows a linear projection applied to the quality parameters and represented by the radial visualization (RadViz). This data visualization allowed the identification of the most influencer parameters for each variety. The proximity between the data point and the parameters (total soluble solids, total polyphenols, tannins and total anthocyanins) highlights the influence of a parameter on the grapevine variety.

Figure 4. Linear projection relating four vectors: total soluble solids, total polyphenols, tannins and total anthocyanins.



Marufo was mostly influenced by the total soluble solids parameter, having low values for the remaining ones. Touriga Franca demonstrated to be more influenced by the total polyphenols. Trincadeira was the variety where the anthocyanins mostly stood out when compared with the other parameters. The same happened with the tannins for the Camarate. In the varieties Vinhão, Malvasia Preta, Tinta Francisca and Roseira the quality parameters were balanced.

4 CONCLUSIONS

This study analysed 19 Portuguese grapevine varieties during two consecutive years, revealing differences on GDD values in the growing season periods and also on

the grape quality. The data was obtained from a specific site (Pinhão, Douro Region) with the same weather conditions. According to this study, it can be pointed out the grapevine varieties with longer growing seasons, high GDD from veraison to harvest and finally with a progressive maturation. These balanced characteristics may provide a better adaptation to the warming scenarios. Aragonez, Roseira, Tinta Carvalha, Tinta Francisca, Touriga Franca and Touriga Fêmea showed high GDD from veraison to harvest, which highlight their better adaptation to the warmer months, based on observed weather conditions of studied years. However, according to the total soluble solids values, Aragonez and Touriga Fêmea seemed to be at their ideal maturation, possibly indicating a higher grape quality vulnerability with the increase of temperature. Among the most adapted grapevine varieties pointed out in this study (Aragonez, Roseira, Tinta Carvalha, Tinta Francisca, Touriga Franca and Touriga Fêmea), Roseira and Tinta Francisca presented the most balanced grape quality parameters, revealing to be suitable minor grapevine varieties in this specific site of the Douro Region, exposed to different weather conditions.

5 ACKNOWLEDGMENTS

The authors acknowledge the financial support of European Investment Funds by FEDER/COMPETE/POCI-Operacional Competitiveness and Internationalization Programme, under Project POCI-01-0145-FEDER-006958 and National Funds by FCT - Portuguese Foundation for Science and Technology, under the project UID/AGR/04033/2019. The authors acknowledge the financial support of European Investment Funds by FEDER/NORTE2020 under the project INNOVINE&WINE, NORTE-01-0145-FEDER-000038.

REFERENCES

- Barnuud N., Zerihun A., Gibberd M., Bates B., 2014. Berry composition and climate: responses and empirical models. *Int. J. Biometeorol.*, **58**, 1207-1223. doi:10.1007/s00484-013-0715-2
- Branas J., Bernon G., Levadoux L., 1946. *Éléments de viticulture générale*. impr. Delmas, Montpellier, France.
- Brito M., Moutinho-Pereira J., Brites M., Magalhães N., 2004. Caracterização ecofisiológica de cinco castas tintas da Região Demarcada do Douro. Actas do 6º. Simpósio de Vitivinicultura do Alentejo, 26-28 maio, Évora, volume 1, 159-166 pp.
- Eiras-Dias J., Cunha J., Brazão J., Clímaco P., 2016. Promover e valorizar as castas minoritárias: O exemplo da casta Malvasia de Colares. *Vida Rural*, Junho, 36-38 pp.
- Fraga H., Malheiro A., Moutinho-Pereira J., Santos J.A., 2012. An overview of climate change impacts on European viticulture. *Food Energy Secur.*, **1**(2), 94-110. doi:10.1002/fes3.14

- Fraga H., 2014a. Zonagem vitícola na Europa: cenários climáticos e medidas de adaptação. Tese de doutoramento. UTAD, Vila Real. 198pp.
- Fraga H., Malheiro A., Moutinho-Pereira J., Santos J.A., 2014b. Climate factors driving wine production in the Portuguese Minho region. *Agric. For. Meteorol.*, **185**, 26-36. doi:10.1016/j.agrformet.2013.11.003
- Fraga H., Santos J.A., Malheiro A., Oliveira A.A., Moutinho-Pereira J., Jones G., 2015. Climatic suitability of Portuguese grapevine varieties and climate change adaptation. *Int. J. Climatol.*, **36**(1), 1-12. doi:10.1002/joc.4325
- Fraga H., Santos J.A., Moutinho-Pereira J., Carlos C., Silvestre J., Eiras-Dias J., Mota T., Malheiro A., 2016. Statistical modelling of grapevine phenology in Portuguese wine regions: observed trends and climate change projections. *J. Agric. Sci.*, **154**(5), 795-816. doi:10.1017/S0021859615000933
- Greer D., 2017. Responses of biomass accumulation, photosynthesis and the net carbon budget to high canopy temperatures of *Vitis vinifera* L. cv. Semillon vines grown in field conditions. *Enviro. Exp. Bot.*, **138**, 10-20. doi:10.1016/j.envexpbot.2017.03.001
- Dinis L.-T., Correia C., Ferreira H., Gonçalves B., Gonçalves I., Coutinho J.F., Ferreira M.I., Malheiro A., Moutinho-Pereira, J., 2014. Physiological and biochemical responses of Semillon and Muscat Blanc à Petits Grains winegrapes grown under Mediterranean climate. *Sci Horti.*, **175**, 128-138. doi:10.1016/j.scienta.2014.06.007
- Dobrei A., Dobrei A.G., Nistor E., Iordanescu O., Sala F., 2015. Local Grapevine Germplasm from Western of Romania – an Alternative to Climate Change and Source of Typicity and Authenticity. *Agric. & Agric. Sci. Proc.*, **6**, 124-131. doi: 10.1016/j.aaspro.2015.08.048
- Huglin P., 1978. Nouveau mode d'évaluation des possibilités héliothermiques d'un milieu viticole. Comptes Rendus de l'Académie d'Agriculture. Académie d'agriculture de France, Paris, France.
- Instituto Nacional de Meteorologia e Geofísica., 1988. O Clima de Portugal, Normas Climatológicas da região Entre Douro e Minho e Beira Litoral, correspondentes a 1941 - 1970. Fascículo XL, volume 1 - 1ª região, Lisboa. 70pp.
- IVV., 2018. Castas mais utilizadas. Ministério da Agricultura, Florestas e Desenvolvimento Rural. Instituto da Vinha e do Vinho, I.P., Lisboa.
- Intergovernmental Panel on Climate Change., 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. In: Core Writing Team, Pachauri, R.K., Meyer, L.A. (Eds.), IPCC, Geneva, Switzerland. 151 pp.
- Jones G., Duchêne E., Tomasi D., Yuste J., Braslavská O., Schultz H., Martínez C., Boso S., Langellier F., Perruchot C., Guimberteau G., 2005. Changes in European winegrape phenology and relationships with climate. Paper presented at the Proc. XIV GESCO Symposium, Geisenheim, Germany, August, 23-26.
- Jones G., 2013. Uma Avaliação do Clima para a Região Demarcada do Douro: Uma análise das condições climáticas do passado, presente e futuro para a produção de vinho. Associação para o Desenvolvimento da Viticultura Duriense. Vila Real, Portugal. 102pp.
- Jones N.K., 2012. The influence of recent climate change on wine regions in Quebec, Canada. *J. Wine Res.*, **23**, 103-113. doi:10.1080/09571264.2012.678933
- Kenny G., Shao J., 1992. An assessment of a latitude-temperature index for predicting climate suitability for grapes in Europe. *J. Hort. Sci.*, **67**(2), 239-246. doi:10.1080/00221589.1992.11516243

Lacona T., Sanna M., Spanna F., Schubert A., 2012. Berry Polyphenols and Climatic Variability in Nebbiolo Grapes. IS Viti&Climate: Effect of Climate Change on Production and Quality of Grapevines and Their Products. *Acta Hort.*, 931.

Lopes J., Eiras-Dias J., Abreu F., Clímaco P., Cunha J., Silvestre J., 2008. Exigências térmicas, duração e precocidade de estados fenológicos de castas da coleção ampelográfica nacional. *Ciência Téc. Vitiv.*, **23**, 61-71.

Lopes C., Egipito R., Pedroso V., Pinto P., Braga R., Neto M., 2017. Can berry composition be explained by climatic indices? Comparing classical with new indices in the Portuguese Dão region. IX International Symposium on Grapevine Physiology and Biotechnology. *Act. Hortic.*, 1157.

Lorenzo M., Taboada J., Lorenzo J., Ramos A., 2012. Influence of climate on grape production and wine quality in the Rías Baixas, north-western Spain. *Reg Environ Change*, **13**, 887-896. doi:10.1007/s10113-012-0387-1

Loureiro M., Moreno-Sanz P., Suárez B., 2017. Agronomical characterization of minority grapevine cultivars from Asturias (Spain). *Cienc. Tec. Vitivinic.*, **32**(2), 102-114. doi:10.1051/ctv/20173202102

Magalhães N., Oliveira A.A., Caeiro L., 1995. Contributo para a caracterização climática das regiões vitícolas de Portugal Continental. 3º *Simpósio Vitivinícola do Alentejo*, Évora, 1, 81-90.

Malheiro A., Santos J.A., Fraga H., Pinto J.G., 2010. Climate change scenarios applied to viticultural zoning in Europe. *Clim Res.*, **43**(3), 163-177. doi:10.3354/cr00918

Malheiro A., Campos R., Fraga H., Eiras-Dias J., Silvestre J., Santos J.A., 2013. Winegrape phenology and temperature relationships in the Lisbon Wine Region, Portugal. *J Int Sci Vigne Vin*, **47**(4), 287-299. doi:10.20870/oeno-one.2013.47.4.1558

Matias R., 2017. Establishing a Cooperation Between RadViz and SOM to Improve the Analyst Visual Experience. In: Martínez de Pisón F., Urraca R., Quintián H., Corchado E. (eds) Hybrid Artificial Intelligent Systems. HAIS 2017. Lecture Notes in Computer Science, vol 10334, pp. 354-366. Springer.

Merkouropoulos G., Michailidou S., Alifragkis A., Zioziou E., Koundouras S., Argiriou A., Nikolai N., 2015. A combined approach involving ampelographic description, berry oenological traits and molecular analysis to study native grapevine varieties of Greece. *Vitis*, **54** (Special Issue), 99-103.

Milella R., Pisani R., Mastrofrancesco L., Alba V., Giannandrea M., Gasparro M., Caputo A., 2016. Phenolic characterization and antioxidant capacity of ten autochthonous vines grown in southern Italy. In: *Proc. 39th World Congress of Vine and Wine, Bento Goncalves, Brazil*. Office International de la Vigne et du Vin, BIO Web of Conferences, 7 (Art. 01019). doi:10.1051/bioconf/20160701019

Miranda P.M., Coelho F.E., Tomé A.R., Valente M.A., Carvalho A., Pires C., Pires H.O., Pires V. C., Ramalho C., 2002. "20th century Portuguese Climate and Climate Scenarios", in Santos, F.D., K. Forbes, and R. Moita (eds), 2002, *Climate Change in Portugal: Scenarios, Impacts and Adaptation Measures (SIAM Project)*, 23-83, Gradiva, 454 pp.

Mori K., Goto-Yamamoto N., Kitayama M., Hashizume K., 2007. Effect of high temperature on anthocyanin composition and transcription of flavonoid hydroxylase genes in 'Pinot noir' grapes (*Vitis vinifera*). *J. Hort. Sci. Biotech.*, **82**, 199-206. doi: 10.1080/14620316.2007.11512220

Moutinho-Pereira J., Correia C., Goncalves B., Bacelar E., Torres-Pereira J., 2004. Leaf gas exchange and water relations of grapevines grown in three different conditions. *Photosynthetica*, **42**, 81-86. doi:10.1023/B:PHOT.0000040573.09614.1d

Neuman P, Matzarakis A., 2014. Estimation of wine characteristics using a modified Heliothermal Index in Baden-Wurttemberg, SW Germany. *Int. J. Biometeorol.*, **58**, 407-415. doi:10.1007/s00484-013-0637-z

OIV, 2006. *Recueil des Méthodes Internationales d'Analyse des Vins et des Moûts*. Organization Internationale de la Vigne et du Vin, Paris.

Ramos M., Jones G., Yuste J., 2018. Phenology of Tempranillo and Cabernet-Sauvignon varieties cultivated in the Ribera del Duero DO: observed variability and predictions under climate change scenarios. *OENO One*, **52**(1). doi:10.20870/oenone.2018.52.1.2119

Ramos M., 2017. Projection of phenology response to climate change in rainfed vineyards in north-east Spain. *Agric. For. Meteorol.*, **247**, 104-115. doi:10.1016/j.agrformet.2017.07.022

Rubio-Sánchez M., Raya L., Diaz F., Sanchez, A., 2015. A comparative study between RadViz and Star Coordinates. *IEEE transactions on visualization and computer graphics*, **22**(1), 619-628.

Sadras V., Moran M., 2013. Asymmetric warming effect on the yield and source:sink ratio of field-grown grapevine. *Agric. For. Meteorol.*, **173**, 116-126. doi:10.1016/j.agrformet.2012.12.005

Saleh O., Harb J., Karryt A., Arif M., Frank W., 2018. Identification of differentially expressed genes in two grape varieties cultivated in semi-arid and temperate regions from West-Bank, Palestine. *Agri Gene*, **7**, 34-42. doi:10.1016/j.aggene.2017.11.001

Santos J.A., Malheiro A., Pinto J.G., Jones G., 2012. Macroclimate and viticultural zoning in Europe: observed trends and atmospheric forcing. *Clim Res.*, **51**(1), 89-103. doi:10.3354/cr01056

Santos J.A., Grätsch S., Karremann M., Jones G., Pinto J.G., 2013. Ensemble projections for wine production in the Douro Valley of Portugal. *Clim Change*, **117**(1-2), 211-225. doi:10.1007/s10584-012-0538-x

Selianinov G., 1928. On agricultural climate valuation (in Russian). *Proc. Agric. Meteorol.*, **20**, 165-177

Tomasi D., Jones G., Giust M., Lovat L., Gaiotti F., 2011. Grapevine Phenology and climate change: relationships and trends in the Veneto Region of Italy for 1964–2009. *Am. J. Eno. Vit.*, **62**, 329-339. doi:10.5344/ajev.2011.10108

Tonietto J., Carbonneau A., 2004. A multicriteria climatic classification system for grape growing regions worldwide. *Agric. For. Meteorol.*, **124**(1-2), 81-97. doi:10.1016/j.agrformet.2003.06.001

Winkler A. 1974. *General viticulture*. University of California Press, California, USA.

Van Leeuwen C., Friant P., Chone X., Tregoat O., Koundouras S., Dubourdieu D., 2004. Influence of climate, soil, and cultivar on terroir. *Am. J. Eno. Vit.*, **55**(3), 207-217.

Van Leeuwen C., Seguin, G., 2006. The concept of terroir in viticulture. *J. Wine Res.*, **17**(1), 1-10. doi:10.1080/09571260600633135

SOBRE O ORGANIZADOR

EDUARDO EUGENIO SPERS realizou pós-doutorado na Wageningen University (WUR), Holanda, e especialização no IGIA, França. Possui doutorado em Administração pela Universidade de São Paulo (USP). Foi Professor do Programa de Mestrado e Doutorado em Administração e do Mestrado Profissional em Comportamento do Consumidor da ESPM. Líder do tema Teoria, Epistemologia e Métodos de Pesquisa em Marketing na Associação Nacional de Pós-Graduação e Pesquisa em Administração (ANPAD). Participou de diversos projetos de consultoria e pesquisa coordenados pelo PENZA e Markestrat. É Professor Titular no Departamento de Economia, Administração e Sociologia, docente do Mestrado em Administração e Coordenador do Grupo de Extensão MarkEsalq no campus da USP/Esalq. Proferiu palestras em diversos eventos acadêmicos e profissionais, com diversos artigos publicados em periódicos nacionais e internacionais, livros e capítulos de livros sobre agronegócios, com foco no marketing e no comportamento do produtor rural e do consumidor de alimentos.

ÍNDICE REMISSIVO

A

Abono orgánico 69, 70
Acuicultura 85, 86
Agrohomeopatía 180, 182, 183
Agua de vidrio 180, 182, 183
Alimentación de precisión 93, 96, 99
Amaranthus caudatus 69, 70, 75, 78, 81, 82
Amenazas 169, 170, 173
Anión superóxido 186, 187, 188, 190, 191
Antioxidantes 185, 186, 187, 188, 189, 190, 191, 192, 193, 194
Arbres 13, 14, 15, 16, 17, 18, 20, 22, 25, 27, 28, 30, 31, 32, 33, 35, 36, 37
Arquitectura multiagente 93, 95
Assortiment 13, 14, 16, 19, 23, 25, 32

B

Babesia bigemina 196, 197, 198, 200, 203, 206, 207
Babesia bovis 196, 197, 198, 200, 202, 206
Bioclimatic indexes 127, 128, 129, 130, 132, 134
Bio insumos 180
Brisas de mar y tierra 146, 147, 148, 149, 151, 159

C

Caligus rogercresseyi 84, 85, 86, 91, 92
Catalasa 186, 187, 188, 193, 194
Cítricos 180, 181, 182, 183, 184
Control de calidad 101, 102, 104, 108
Costa del Rio de la Plata 146, 148, 149, 158
Cromatografía en capa fina 101, 102, 104, 106, 109

D

Disease control 42, 43
Diversidad genética 114, 115, 169, 170, 172, 174, 175

E

Éclaircie 13, 14, 15, 16, 20, 24, 25, 29, 30, 31, 32, 33

Économie 13

Eficiência no uso da água 1, 3

Estiércol 162, 163, 167, 168

F

Fertilización química 162

G

Growing Degree Days 127, 128, 129, 132, 135

I

Infusión 102, 103, 104, 105

Integración del hardware de proveedores 93

K

Kiwicha 69, 70, 71, 73, 75, 76, 77, 78, 79, 80, 81, 82

L

Labranza de conservación 162, 166

Lenguaje de comunicación entre agentes 93

M

Machine learning 84, 85, 86, 90, 92

Maíz 57, 58, 61, 62, 63, 64, 65, 66, 67, 68, 71, 161, 162, 163, 164, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178

Maturation 128, 129, 130, 132, 139, 140, 141, 142

Medicina tradicional 101, 102, 103

Microclima de canopia 146, 158

Milpa 57, 58, 63, 65, 68, 169, 170, 172, 173, 174, 176, 177

Minor grapevine varieties 128, 130, 131, 142

N

Nueva enfermedad 180

O

Olivais de elevada densidade 1, 3, 5, 6, 7, 9

Olivais de regadio 1

P

PCR-RFLP 196, 197, 199, 200, 201, 202, 203, 204, 205, 206, 207

Production forestière 13, 16

Productividad 58, 59, 63, 67, 84, 94, 172

R

Rega deficitária 1, 5, 6, 7, 9

Remedios herbolarios 102, 105, 110

RNA 112, 113, 115, 124, 196, 197, 199, 203, 206

RT-PCR 112, 113, 114, 115, 117, 118, 119, 120, 126

S

Saccharum spp 112, 113, 118, 119, 121

Salmonidos 84, 85, 86, 87, 88, 89, 90

SCYLV 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124

Spraying 42, 43, 44, 49, 56

Superóxido dismutasa 185, 186, 187, 188, 192, 193, 194

T

Trucha arcoíris 85, 86, 87, 89, 90, 185, 186, 187, 188, 189, 190, 191, 192, 193

U

Unidad de producción 58, 62, 66, 67, 68

V

Viñedo 146, 147, 148, 149, 150, 151, 153, 154, 156, 157, 159

Viticulture 42, 43, 130, 142, 145, 160