

Ciência e Tecnologia

Para o Desenvolvimento
Ambiental, Cultural
e Socioeconômico

Xosé Somoza Medina
(organizador)

VOL VI

 EDITORA
ARTEMIS
2025

Ciência e Tecnologia

Para o Desenvolvimento Ambiental, Cultural e Socioeconômico

Xosé Somoza Medina
(organizador)

VOL VI

 EDITORA
ARTEMIS
2025



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. Xosé Somoza Medina
Imagem da Capa	peacestock/123RF
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, Brasil
Prof. Dr. Agustín Olmos Cruz, *Universidad Autónoma del Estado de México*, México
Prof.^a Dr.^a Amanda Ramalho de Freitas Brito, Universidade Federal da Paraíba, Brasil
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, Brasil
Prof.^a Dr.^a Begoña Blandón González, *Universidad de Sevilla*, Espanha
Prof.^a Dr.^a Carmen Pimentel, Universidade Federal Rural do Rio de Janeiro, Brasil
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, Brasil
Prof. Dr. Cleberton Correia Santos, Universidade Federal da Grande Dourados, Brasil
Dr. Cristo Ernesto Yáñez León – New Jersey Institute of Technology, Newark, NJ, Estados Unidos
Prof. Dr. David García-Martul, *Universidad Rey Juan Carlos de Madrid*, Espanha
Prof.^a Dr.^a Deuzimar Costa Serra, Universidade Estadual do Maranhão, Brasil
Prof.^a Dr.^a Dina Maria Martins Ferreira, Universidade Estadual do Ceará, Brasil
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 (USP), Brasil
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. Fernando Hitt, *Université du Québec à Montréal*, Canadá

Prof. Dr. Gabriel Díaz Cobos, *Universitat de Barcelona*, Espanha

Prof.^a Dr.^a Gabriela Gonçalves, Instituto Superior de Engenharia do Porto (ISEP), Portugal

Prof.^a Dr.^a Galina Gumovskaya – Higher School of Economics, Moscow, Russia

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. Guillermo Julián González-Pérez, *Universidad de Guadalajara*, México

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 Godínez, Universidad Autónoma de Baja California, México

Prof. Dr. Juan Carlos Cancino Díaz, 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. Juan Porras Pulido, *Universidad Nacional Autónoma de México*, 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 Rodriguez, *Universidad Santiago de Compostela*, Espanha

Prof. Dr. Manuel Simões, Faculdade de Engenharia da Universidade do Porto, Portugal

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 María Alejandra Arecco, *Universidad de Buenos Aires*, Argentina

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 da Luz Vale Dias – Universidade de Coimbra, Portugal
 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 MªGraça Pereira, Universidade do Minho, Portugal
 Prof.ª Dr.ª Maria Gracinda Carvalho Teixeira, Universidade Federal Rural do Rio de Janeiro, Brasil
 Prof.ª Dr.ª María Guadalupe Vega-López, *Universidad de Guadalajara, México*
 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. Dr. Melchor Gómez Pérez, Universidad del Pais Vasco, Espanha
 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. Sérgio Bitencourt Araújo Barros, Universidade Federal do Piauí, Brasil
 Prof. Dr. Sérgio Luiz do Amaral Moretti, Universidade Federal de Uberlândia, Brasil
 Prof.ª Dr.ª Silvia Inés del Valle Navarro, *Universidad Nacional de Catamarca, Argentina*
 Prof.ª Dr.ª Solange Kazumi Sakata, Instituto de Pesquisas Energéticas e Nucleares (IPEN)- USP, Brasil
 Prof.ª Dr.ª Stanislava Kashtanova, *Saint Petersburg State University, Russia*
 Prof.ª Dr.ª Susana Álvarez Otero – Universidad de Oviedo, Espanha
 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)

C569 Ciência e tecnologia para o desenvolvimento ambiental, cultural e socioeconômico VI [livro eletrônico] / Organizador Xosé Somoza Medina. – Curitiba, PR: Artemis, 2025.

Formato: PDF

Requisitos de sistema: Adobe Acrobat Reader

Modo de acesso: World Wide Web

Inclui bibliografia

Edição bilíngue

ISBN 978-65-81701-51-2

DOI 10.37572/EdArt_290525512

1. Desenvolvimento sustentável. 2. Tecnologia – Aspectos ambientais. I. Somoza Medina, Xosé.

CDD 363.7

Elaborado por Maurício Amormino Júnior – CRB6/2422



PRÓLOGO

La ciencia y la tecnología siguen siendo fuerzas impulsoras de las transformaciones sociales, culturales y ambientales de nuestro tiempo. Al mismo tiempo que responden a desafíos urgentes del presente, también iluminan caminos hacia futuros más sostenibles, más justos e inteligentes. Esta recopilación nace precisamente de ese impulso: el de pensar, crear y proponer soluciones a partir de la investigación científica y la innovación tecnológica, en diálogo con las realidades locales y los contextos globales.

Reunimos en ***Ciência e Tecnologia para o Desenvolvimento Ambiental, Cultural e Socioeconômico VI*** artículos de investigadores e investigadoras de distintas partes del mundo, comprometidos con la producción de un conocimiento riguroso, interdisciplinario y sensible a la complejidad de los temas contemporáneos. Los trabajos presentados abordan una amplia gama de cuestiones – desde la nanotecnología hasta la agricultura de precisión, desde la física aplicada hasta la expresión lingüística – conformando un panorama diverso que refleja los múltiples caminos de la ciencia en el siglo XXI.

Organizados en cuatro ejes temáticos – *Tecnología e Innovación en Salud e Industria, Ingeniería, Física Aplicada y Recursos Naturales, Sustentabilidad Agrícola y Transformaciones Climáticas, y Lenguaje, Cognición y Expresión Científica* – los textos aquí reunidos nos invitan a reflexionar sobre preguntas centrales de nuestro tiempo: ¿Cómo garantizar el acceso equitativo a las nuevas tecnologías médicas? ¿Cómo integrar soluciones de ingeniería a las urgencias ambientales? ¿De qué manera puede el avance agrícola responder al cambio climático sin agotar los recursos naturales? ¿Y cómo influye el lenguaje en la forma en que comprendemos y comunicamos el conocimiento científico?

Más que ofrecer respuestas definitivas, esta obra propone caminos para la reflexión y la acción, abriendo espacio para nuevas investigaciones, debates y colaboraciones. Cada autor y autora aporta una perspectiva única, y juntas estas voces amplían nuestra comprensión del papel transformador de la ciencia y la tecnología en el mundo contemporáneo.

Que este nuevo libro sea, para lectoras y lectores, una invitación a la curiosidad crítica, al pensamiento creativo y a la construcción de futuros posibles. Agradecemos a todos los involucrados por su confianza, dedicación y generosidad intelectual.

Xosé Somoza Medina

Universidad de León, Espanha

SUMÁRIO

TECNOLOGIA E INOVAÇÃO EM SAÚDE E INDÚSTRIA

CAPÍTULO 1..... 1

NAVEGANDO LOS DESAFÍOS EN LA NANOMEDICINA: ÉTICA, ACCESO Y PARTICIPACIÓN PÚBLICA

Jade Cristi Rivera Rossi

 https://doi.org/10.37572/EdArt_2905255121

CAPÍTULO 2..... 7

APLICACIÓN DE LA ELECTRICIDAD Y LA ELECTRÓNICA EN LA INGENIERÍA INDUSTRIAL: INTEGRACIÓN DE SENSORES, ELECTRO-NEUMÁTICA Y CONTROLADORES LÓGICOS PROGRAMABLES

Miguel Ángel Quiroz García

María del Carmen Nolasco Mata

Marycarmen Arana Altamirano

Violeta del Rocío Hernández Campos

Raymundo Escalante Wong

 https://doi.org/10.37572/EdArt_2905255122

ENGENHARIA, FÍSICA APLICADA E RECURSOS NATURAIS

CAPÍTULO 3..... 21

SOLUCIÓN A LA ECUACIÓN DE ONDA PROPAGADA RADIALMENTE PARA EL CAMPO ELÉCTRICO EN COORDENADAS CILÍNDRICAS

Esteban Andrés Zárate

Mateo Márquez Arias

Israel Benjamín Sánchez Jiménez

Quintiliano Angulo Córdova

 https://doi.org/10.37572/EdArt_2905255123

CAPÍTULO 4..... 31

ANÁLISIS COMPARATIVO DE LAS VARIACIONES DEL COMPORTAMIENTO DEL FUEGO, DURANTE UNA QUEMA PRESCRITA

José German Flores-Garnica

 https://doi.org/10.37572/EdArt_2905255124

CAPÍTULO 5..... 46

DIAGNÓSTICO EXPERIMENTAL DO PROBLEMA DE REBAIXAMENTO DAS ÁGUAS SUBTERRÂNEAS NA REGIÃO DE BISKRA (ARGÉLIA)

Abderrahmane Noui

Zineb Guesbaya

 https://doi.org/10.37572/EdArt_2905255125

SUSTENTABILIDADE AGRÍCOLA E TRANSFORMAÇÕES CLIMÁTICAS

CAPÍTULO 6..... 60

BREEDING DROUGHT RESISTANCE AND HEAT TOLERANCE TO MITIGATE CLIMATIC CHANGE EFFECTS ON CROPS

Cándido López-Castañeda

 https://doi.org/10.37572/EdArt_2905255126

CAPÍTULO 7..... 68

CULTIVARES DE COENTRO FERTILIZADO COM A MISTURA DE ADUBOS ORGÂNICOS INCORPORADO AO SOLO NA REGIÃO SEMIÁRIDA 68

Paulo César Ferreira Linhares

Patrício Borges Maracajá

Aline Carla de Medeiros

José Nilson de Matos Fernandes

Lunara de Sousa Alves

Karen Geovana da Silva Carlos

Joaquim Odilon Pereira

Walter Martins Rodrigues

Fagno Dallino Rolim

Sonally Yasnara Sarmiento Medeiros Abrantes

Ordânio Pereira de Almeida

Maria Eduarda Sarmiento Medeiros Abrantes

 https://doi.org/10.37572/EdArt_2905255127

CAPÍTULO 8.....82

ADUBAÇÃO ORGÂNICA COM FLOR-DE-SEDA (*Calotropis procera*) EM ADIÇÃO COM ESTERCO BOVINO NA PRODUÇÃO DE RABANETE

Paulo César Ferreira Linhares

Lunara de Sousa Alves

Wyara Ferreira Melo

Aline Carla de Medeiros
Joaquim Odilon Pereira
Walter Martins Rodrigues
Karen Geovana da Silva Carlos
Sonally Yasnara Sarmiento Medeiros Abrantes
Maria Eduarda Sarmiento Medeiros Abrantes
Andressa Pedroza Pereira da Silva
Ordânio Pereira de Almeida
Fagno Dallino Rolim
Francisco Andesson Bezerra da Silva

 https://doi.org/10.37572/EdArt_2905255128

CAPÍTULO 9.....92

AGRICULTURA DE PRECISÃO E FORMAÇÃO DIGITAL: O PAPEL TRANSFORMADOR DOS AGRICULTORES NO PROJETO HIBA

Elsa da Piedade Chinita Soares Rodrigues

 https://doi.org/10.37572/EdArt_2905255129

CAPÍTULO 10.....107

INFLUENCIA DE LA CONCENTRACIÓN DE ARSÉNICO EN LA TRANSFERENCIA DE MATERIA EN ZANAHORIAS COCIDAS

Oscar Daniel Galvez
Mariela Beatriz Maldonado
Juan Ignacio González Pacheco

 https://doi.org/10.37572/EdArt_29052551210

LINGUAGEM, COGNIÇÃO E EXPRESSÃO CIENTÍFICA

CAPÍTULO 11..... 116

THE EXPRESSION TECHNIQUES OF “IRREVOCABLE SADNESS” AND “INVISIBILITY”: BRAUTIGAN’S POETICS AS UNVERBALIZED ABSENCE THE SYMBOLIC FUNCTION OF SPECIFIC NUMBERS (3003, 45, 33) AND THE INTERSECTION OF CYCLICAL TIME, ETERNAL PRESENT, AND POETIC NUMEROLOGY IN WORKS FROM EARLY “THE MARBLE TEA” TO FINAL “SO THE WIND WON’T BLOW IT ALL AWAY” (AMERICAN LITERARY TRENDS 1950S-1980S)

Yasuko Kawahata

 https://doi.org/10.37572/EdArt_29052551211

CAPÍTULO 12138

FROM “NAI” (“NOT”) TO “MIRU” (“TO SEE”): AN ANALYSIS OF THE MULTI-LAYERED
STRUCTURE OF LINGUISTIC RHYTHMS – TRACING THE FORMATION OF THE
DIGITAL PUBLIC SPHERE AND SOCIAL SYNCHRONIZATION PHENOMENA THROUGH
BASIC JAPANESE VOCABULARY FROM JANUARY 2011 TO MARCH 2015 –

Yasuko Kawahata



https://doi.org/10.37572/EdArt_29052551212

SOBRE O ORGANIZADOR..... 161

ÍNDICE REMISSIVO162

CAPÍTULO 6

BREEDING DROUGHT RESISTANCE AND HEAT TOLERANCE TO MITIGATE CLIMATIC CHANGE EFFECTS ON CROPS

Data de submissão: 20/03/2025

Data de aceite: 11/04/2025

Cándido López-Castañeda

Postgrado en Recursos Genéticos y

Productividad-Genética

Colegio de Postgraduados

Campus Montecillo

Carretera México-Texcoco

km 36.5CP 56230

Montecillo, Texcoco, Estado de México

<https://orcid.org/0000-0001-5342-7962>

ABSTRACT: The objective of this study was to assess the plant response to soil water deficit and heat in a group of bread wheat, triticale and barley varieties under glasshouse and outdoors conditions. Thirty-two bread wheats, two barleys and a triticale were included. A complete block design with three replicates was used. The experimental unit was a PVC tube 1 m tall and 10.5 cm diameter with an individual plant. Both experiments were planted in July 28, 2010. A fertilizer rate of 80-40-00 was applied to the soil. This showed that plants under water and heat stress in a glasshouse produced less biomass, dry weight of roots and shoot, and had lower root/shoot ratio than plants with less heat stress outdoors. The barley varieties

produced greater biomass and dry weight of roots and shoot, and they had greater root/shoot ratio than the bread wheat and triticale varieties in glasshouse conditions with higher level of water and heat stress. The better performance of barley varieties in glasshouse conditions could be used as a valuable attribute of drought resistance and heat tolerance, and it could be used as a selection criterion in the plant breeding programs.

KEYWORDS: *Hordeum vulgare* L.; *Triticum aestivum* L.; *Triticosecale* Wittmack; dry weight of roots; dry weight of shoot.

RESISTENCIA A LA SEQUÍA Y TOLERANCIA AL CALOR PARA MITIGAR LOS EFECTOS DEL CAMBIO CLIMÁTICO EN LOS CULTIVOS

RESUMEN: El objetivo del presente estudio fue evaluar la respuesta de la planta al déficit hídrico del suelo y calor en un grupo de variedades de trigo harinero, triticale y cebada en condiciones de invernadero e intemperie. Se incluyeron 32 genotipos de trigo harinero, dos cebadas y un triticale. Se empleó un diseño experimental de bloques completos al azar con tres repeticiones. La unidad experimental fue un tubo de PVC de 1 m de alto y 10.5 cm de diámetro con una planta individual. Los dos experimentos se sembraron el 28 de julio de 2010. Se aplicó la dosis de fertilización 80-40-00. Se determinó que las plantas sujetas a estrés hídrico y alta temperatura en invernadero produjeron menos biomasa,

peso seco de raíces y parte aérea, y tuvieron menor cociente de raíz/parte aérea que las plantas con menor estrés por calor en condiciones de intemperie. Las variedades de cebada produjeron mayor biomasa, peso seco de raíces y parte aérea, y tuvieron mayor cociente raíz parte aérea que las variedades de trigo harinero y triticales en condiciones de invernadero con mayor nivel de estrés hídrico y por calor. El mejor comportamiento genético de las variedades de cebada en condiciones de invernadero puede considerarse como un atributo de resistencia a sequía y tolerancia a calor, y podría utilizarse como criterio de selección en los programas de mejoramiento genético.

PALABRAS CLAVE: *Hordeum vulgare* L.; *Triticum aestivum* L.; *Triticosecale* Wittmack; peso seco de raíz; peso seco de parte aérea.

1 INTRODUCTION

Global food security is being haunted by the rapid increase in population and drastic changes in the climate (Lesk *et al.*, 2016). In the wake of changing climate, drought, and heat stress have become the most important limiting factors to crop productivity and ultimately to the food security. Severe droughts cause substantial decline in crop yields through negative impacts on plant growth, physiology, and reproduction (Barnabas *et al.*, 2008). Average global combined temperature of land and ocean surface has increased by 0.85 °C between 1880 and 2012 (IPCC, 2014). An average increase of at least 0.2 °C per decade is projected from now onwards. The rising concentration of the greenhouse gases is becoming a major cause of the global warming. Over the past 250 years a 30 and 150 % rise in the concentration of the CO₂ and methane has been observed (Friedlingstein *et al.*, 2010). Drought and heat stresses limit plant growth and productivity more than any other environmental factor. For instance, global wheat production was simulated to decline by 6 % for each degree Celsius rise in temperature (Asseng *et al.*, 2015). Although increasing temperatures are also beneficial for crop production in some cooler regions of the world, overall impact on global food security is still negative (Challinor *et al.*, 2014). Plants are subjected to the drought conditions when either the water supply to the roots is limited or the loss of water through transpiration is very high (Anjum *et al.*, 2011). The severity of the damage caused by the drought is generally unpredictable as it is driven by various factors including, the rainfall patterns, moisture holding capacity of the soil, and water losses through evapotranspiration. Drought and heat stresses interfere with growth, nutrient and water relations, photosynthesis, assimilate partitioning and ultimately cause a significant reduction in crop yields. The present research work was pursued to assess the response of a group of bread wheat, barley and triticales genotypes under drought and heat stress in glasshouse and outdoors conditions.

2 MATERIALS AND METHODS

Two experiments in large tubes were carried on at Colegio de Postgraduados at Montecillo, Municipality of Texcoco, State of Mexico (19° 29' N, 98° 54' O, elevation 2250 m above sea level) in the summer-fall growing season 2010. Thirty-two genotypes of bread wheat representing a historical sample of old and modern bread wheats from Mexico and the United States of America, and a triticale and two barley genotypes were included (Table 1).

Table 1. Germplasm used for the experiments.

Pedigree	Year of release	Country of origin	Plant genetic characteristics
Old Mexican landraces			
Kentana 48	1948	Mexico	Tall (rht), bread wheat
Yaqui 50	1950	Mexico	Tall (rht), spring
Temp. M-87/Col.1718 CPRST-13-13T (F ₄)	1998	Mexico	Tall
Yaqui 48	1948	Mexico	Tall, (rht), awnless
Old parental green-revolution lines			
Gabo	1945	Australia	Tall, (rht), bread wheat
Marroqui	1948	Morocco, North Africa	Tall, (rht), bread wheat
Pre-breeding genotypes of the green-revolution			
Nainari 60	1960	Mexico	Tall, (rht), bread wheat
Penjamo 62	1962	Mexico	Tall, (rht), spring
Bajio 67	1967	Mexico	Tall, (rht), spring
Tobari 66	1966	Mexico	Tall, (rht), bread wheat
Green-revolution genotypes			
Decade 1970's			
Salamanca S-75	1975	Mexico	Semi-dwarf
Cleopatra VS-74	1974	Mexico	Semi-dwarf
Tanori F-71	1971	Mexico	Semi-dwarf
Jupateco F-73	1973	Mexico	Semi-dwarf
Yecora Rojo	1975	USA	Semi-dwarf
Decade 1980's			
Galvez M-87	1987	Mexico	Semi-dwarf
Mexico M-82	1982	Mexico	Tall
Tonichi S-81	1981	Mexico	Semi-dwarf
Seri M-82	1982	Mexico	Semi-dwarf
Genaro T-81	1981	Mexico	Semi-dwarf

Opata 85 (Cheel)	1985	Mexico	Semi-dwarf
Decade 1990's			
Verano S-91	1991	Mexico	Semi-dwarf
Romoga F-96	1996	Mexico	Semi-dwarf
Juchitepec	1996	Mexico	Semi-dwarf
Borlaug M-95	1995	Mexico	Short
Modern			
Nahuátl F-2000	2000	Mexico	Semi-dwarf
Rebeca F-2000	2000	Mexico	Semi-dwarf
Era F 2000	2000	Mexico	Semi-dwarf
Tlaxcala F-2000	2000	Mexico	Semi-dwarf
Summit	2005	CA, USA	Semi-dwarf
Blanca Grande	2005	CA, USA	Semi-dwarf
Other bread wheats			
Cal Rojo	-	Los Altos, CA, USA	Tall
Triticale			
Triticale 118 (Spring)	-	CA, USA	Tall, spring
Barley			
Lenetah (Barley, spring, two-row)	-	Idaho, USA	Tall, two-row, spring
Cleopatra (Barley, spring, six-row)	-	Mexico	Tall, six row, spring

Experiments were sown in July 28, 2010 in wet soil; one experiment was placed in a glasshouse and the another one was set up outdoors. Seeds of 35 mg weight were used for all genotypes. A complete randomized block design with three replicates was used. The experimental unit was an individual plant grown in a large PVC tube (1 m tall and 10.5 cm diameter) filled out with soil. Soil used was a silt-loam, rich in organic matter with 33.9 % field capacity, 20.5 % permanent wilting percentage, 9 % organic matter, 6.9 pH and 1.5 dSm⁻¹ electric conductivity. Nitrogen and phosphorous were applied to the soil at a rate of 80 and 40 kg ha⁻¹, respectively. Plants grown in glasshouse conditions were watered every other day up to flowering and plants grown outdoors were exposed to rainfall (462 mm) and they were added with water as needed up to flowering. Soil born pests and diseases were prevented with the application of Quatz® IV, Twin-Chain (Alterna-agro, s.a. de c.v., Mexico) at a dosage of 1L ha⁻¹ 25 days after sowing. Neither pests nor diseases were observed on the aerial plant organs.

At physiological maturity whole shoot was removed and placed in paper bags to be oven dried for 72 h at a temperature of 70 °C. Dry weight of shoot (DWS, g) was determined for all plants. Plant roots in large tubes were left in a glasshouse until the soil

dried up. Then, plastic bags with soil and roots were placed on a table and length of the longest root (LR, cm) was measured from the soil surface to the root tip with a wooden ruler. Roots were separated from soil and they were taken to an oven and dry weight (DWR, mg) was determined. Plant biomass (BM = DWR + DWS, g) and root/shoot ratio (RSR = DWR / DWS) were calculated. Maximum and minimum temperatures were recorded by using a data logger (Hobo® model H08-004-02, United States) placed at 1.8 m height from the soil surface in both experiments. Rainfall occurred in the outdoors experiment was measured with a gauge (Young Tipping Bucking Rain Gauge, model 52202/52203, United States) (Table 2). Data were analyzed using the SAS Program for Windows version 9.4 (SAS, 2012). Least significant difference (Lsd Tukey, $P \leq 0.05$) was calculated for the comparison of means.

Table 2. Monthly weather statistics during the growing season.

Environment	May	June	July	August	September	October
Glasshouse						
Maximum temperature (°C)	35.8	34.1	31.3	30.1	30.2	30.4
Minimum temperature (°C)	11.1	12.6	12.5	11.9	11.4	7.1
Outdoors						
Maximum temperature (°C)	33.7	32.9	27.3	26.8	26.4	25.4
Minimum temperature (°C)	6.3	8.6	10.1	9.2	8.2	0.5
Precipitation (mm)	10.5	49.2	208.6	149.5	44.3	0.0

3 RESULTS AND DISCUSSION

Soil moisture deficit after flowering caused water stress in the glasshouse and outdoors plants. Water stress in the glasshouse plants was increased by the higher mean maximum and minimum air temperatures (32 and 11.1 °C) than in the outdoors plants (28.8 and 7.2 °C). Exposure of bread wheat plants to suboptimal (below 2 °C) or super optimal (25 °C) temperatures may reduce grain yields by inducing pollen sterility (Sánchez *et al.*, 2014).

Genetic variability among genotypes of bread wheat, barley and triticale for all measured plant traits was significant, except for the length of the longest root in the outdoors plants. The range of variation among genotypes for biomass, dry weight of roots, dry weight of shoot, root/shoot ratio and length of the longest root was higher (12.7, 37.5, 12.2, 10.3 and 2.2-fold) in the glasshouse plants than in the outdoors plants (2.4, 9.0, 2.3, 9.7

and 1.9-fold) (Table 3). The fold range variation for dry weight of roots and shoot, observed in this study was greater than that determined in seedlings of durum wheat grown in phytoagar gel in laboratory conditions, where the range fold for dry weight of roots and shoot was 1.7 and 1.5, respectively (Sanguineti *et al.*, 2007). Differences in root and shoot growth between these experiments and the laboratory experiment of Sanguineti *et al.* (2007) were due to the longer growth period given to the glasshouse and outdoors plants; this allowed a greater root and shoot development at physiological maturity. The lack of difference in length of the longest root among genotypes in the outdoors experiment was probably due to the high level of precipitation and greater soil moisture availability before flowering of plants.

Table 3. Fold range, significance of F and mean, minimum and maximum values for total biomass (BM), dry weight of roots (DWR), dry weight of shoot (DWS), root/shoot ratio (RSR) and length of the longest root length (RL) in the glasshouse and outdoors plants.

Genotype	Glasshouse					Outdoors				
	BM (g)	DWR (g)	DWS (g)	RSR	RL (cm)	BM (g)	DWR (g)	DWS (g)	RSR	RL (cm)
Mean	4.48	0.08	4.4	0.018	38.8	17.9	0.3	17.6	0.020	46.9
Minimum	1.52	0.02	1.50	0.004	24.7	10.9	0.1	10.8	0.006	34.8
Maximum	19.05	0.75	18.3	0.041	54.7	25.7	0.9	25.2	0.058	67.8
Fold range	12.7	37.5	12.2	10.3	2.2	2.4	9.0	2.3	9.7	1.9
Significance	**	**	**	**	*	*	**	*	*	ns
CV (%)	43.3	65.3	41.8	52.1	33.2	25.9	66.4	26.2	72.9	25.7

F value: *($P \leq 0.05$); **($P \leq 0.01$); ns=no significant.

Genetic variability in root and shoot traits among species showed that barley had 80, 90, 79 and 60 % higher BM, DWR, DWS and RSR, and 11 cm extra length of the longest root than bread wheat, and 68, 69, 68 and 2 % greater BM, DWR, DWS and RSR than triticale in the glasshouse plants (Table 4). Unexpectedly, in the outdoors experiment, triticale had 43 and 48 % greater DWR and RSR than barley, and 28, 43, 27 and 39 higher BM, DWR, DWS and RSR than bread wheat (Table 4). The higher BM, DWR, DWS and RSR in barley than bread wheat and triticale in the glasshouse was similar to that observed among barley, bread wheat, durum wheat, triticale and oat by the 2-leaf stage in a growth cabinet (López-Castañeda *et al.*, 1996). However, the outstanding behavior of triticale in the outdoors experiment as compared with bread wheat and barley may be ascribed to less heat stress as air temperatures outdoors were cooler than in the glasshouse plants.

Table 4. Biomass (BM), dry weight of roots (DWR), dry weight of shoot (DWS), root/shoot ratio (RSR) and root length of the longest root (RL) in the glasshouse and outdoors plants.

Species	Glasshouse					Outdoors				
	BM (g)	DWR (g)	DWS (g)	RSR	RL (cm)	BM (g)	DWR (g)	DWS (g)	RSR	RL (cm)
Barley	18.19	0.55	17.64	0.0308	48.9	24.0	0.4	23.6	0.016	48.3
Triticale	5.80	0.17	5.63	0.0302	43.3	23.7	0.7	23.0	0.031	48.5
Bread wheat	3.58	0.05	3.53	0.0123	37.9	17.1	0.3	16.8	0.019	46.7
Lsd (P≤0.05)	1.2	0.08	1.09	0.0041	7.6	2.7	0.1	2.7	0.008	7.1

Finally, the results outlined here show the importance of roots and shoot in the response of plants to water and heat stress. There is no doubt that the roots have a direct connection with the shoot in a such way that the perception of soil water deficit triggers the signals to the shoot. So, that the plant may react quickly performing the necessary physiological adjustments to ensure survival and accumulation of dry matter in the reproductive organs.

4 CONCLUSIONS

Glasshouse plants experienced greater level of water and heat stress than outdoors plants; glasshouse plants produced lower biomass dry weight of roots and shoot, and they had lower root to shoot ratio than outdoors plants. Barley produced greater biomass, dry weight of roots and shoot, and had root to shoot ratio than bread wheat and triticale in glasshouse conditions with high water and heat stress, but in outdoors conditions with less heat stress triticale was the outstanding species.

REFERENCES

Anjum, S. A., L. C. Wang, M. Farooq, M. Hussain, L. L. Xue, and C. M. Zou. 2011. Brassinolide application improves the drought tolerance in maize through modulation of enzymatic antioxidants and leaf gas exchange. *Journal of Agronomy and Crop Science* 197:177-185. doi:10.1111/j.1439-037X.2010.00459.x.

Asseng, S. *et al.*, 2015. Rising temperatures reduce global wheat production. *Nature Climate Change* 5:143-147.

Barnabas, B., Jäger, K., and Fehér, A. 2008. The effect of drought and heat stress on reproductive processes in cereals. *Plant, Cell and Environment* 31:11-38.

Challinor, A. J., J. Watson, D. B. Lobell, S. M. Howden, D. R. Smith, and N. Chhetri. 2014. A meta-analysis of crop yield under climate change and adaptation. *Nature Climate Change* 4:87-291.

Friedlingstein, P., R. A. Houghton, G. Marland, J. Hackler, T. A. Boden, T. J. Conway *et al.* 2010. Update on CO₂ emissions. *Nature Geoscience* 3:811–812.

IPCC. 2014. “Climate Change 2014: Synthesis Report,” in *Proceedings of the Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. Core Writing Team, R. K. Pachauri, and L. A. Meyer (Geneva: IPCC), 151.

Lesk, C., P. Rowhani and N. Ramankutty. 2016. Influence of extreme weather disasters on global crop production. *Nature* 529:84–87.

López-Castañeda, C., R.A. Richards, G.D. Farquhar and R.E. Williamson. 1996. Seed and seedling characteristics contributing to variation in early vigor among temperate cereals. *Crop Science* 36:1257-1266.

Sánchez, B., A. Rasmussen and J. R. Porter. 2014. Temperatures and the growth and development of maize and rice: a review. *Global Change Biology* 20:408–417.

Sanguineti, M.C., S. Li., M. Maccaferri, S. Corneti, F. Rotondo, T. Chiari and R. Tuberosa. 2007. Genetic dissection of seminal root architecture in elite durum wheat germplasm. *Annals of Applied Biology* 151:291-305.

SAS. 2012. SAS 9.4 for windows. SAS Institute Inc., Cary, NC, USA.

Xosé Somoza Medina (1969, Ourense, España) Licenciado con Grado y premio extraordinario en Geografía e Historia por la Universidad de Santiago de Compostela (1994). Doctor en Geografía e Historia por la misma universidad (2001) y premio extraordinario de doctorado por su Tesis “Desarrollo urbano en Ourense 1895-2000”. Profesor Titular en la Universidad de León, donde imparte clases desde 1997. En la Universidad de León fue Director del Departamento de Geografía entre 2004 y 2008 y Director Académico de la Escuela de Turismo entre 2005 y 2008. Entre 2008 y 2009 ejerció como Director del Centro de Innovación y Servicios de la Xunta de Galicia en Ferrol. Entre 2007 y 2009 fue vocal del comité “Monitoring cities of tomorrow” de la Unión Geográfica Internacional. En 2012 fue Director General de Rehabilitación Urbana del Ayuntamiento de Ourense y ha sido vocal del Consejo Rector del Instituto Ourensano de Desarrollo Local entre 2011 y 2015. Ha participado en diversos proyectos y contratos de investigación, en algunos de ellos como investigador principal, con temática relacionada con la planificación urbana, la ordenación del territorio, las nuevas tecnologías de la información geográfica, el turismo o las cuestiones demográficas. Autor de más de 100 publicaciones relacionadas con sus líneas de investigación preferentes: urbanismo, turismo, gobernanza, desarrollo, demografía, globalización y ordenación del territorio. Sus contribuciones científicas más importantes se refieren a la geografía urbana de las ciudades medias, la crisis del medio rural y sus posibilidades de desarrollo, la evolución del turismo cultural como generador de transformaciones territoriales y más recientemente las posibilidades de reindustrialización de Europa ante una nueva etapa posglobalización. Ha participado como docente en masters y cursos de especialización universitaria en Brasil, Bolivia, Colombia, Paraguay y Venezuela y como docente invitado en la convocatoria Erasmus en universidades de Bulgaria (Sofia), Rumanía (Bucarest) y Portugal (Porto, Guimarães, Coimbra, Aveiro y Lisboa). Ha sido evaluador de proyectos de investigación en la Agencia Estatal de Investigación de España y en la Organización de Estados Iberoamericanos (OEI). Como experto europeo en Geografía ha participado en reuniones de la Comisión Europea en Italia y Bélgica. Impulsor y primer coordinador del proyecto europeo URBACT, “come Ourense”, dentro del Programa de la Unión Europea “Sostenibilidad alimentaria en comunidades urbanas” (2012-2014). Dentro de la experiencia en organización de actividades de I+D+i se pueden destacar la organización de diferentes reuniones científicas desarrolladas dentro de la Asociación de Geógrafos Españoles (en 2002, 2004, 2012 y 2018).

ÍNDICE REMISSIVO

A

Adubação orgânica 82, 83, 90

Agricultores 49, 57, 69, 70, 71, 72, 77, 84, 85, 92, 93, 94, 95, 96, 98, 99, 100, 101, 102, 103, 104, 105

Agricultura familiar 69, 83

Águas subterrâneas 46, 47, 48, 51, 52, 53, 54, 55, 56, 57, 101, 108

Argélia 46, 47, 48, 49

Arsênico 107, 108, 109, 110, 111, 112, 113, 114, 115

Atenuación 21, 29, 30

B

Biskra 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59

C

Cargas de combustibles 31, 33, 34, 36, 37, 38, 42

Coeficientes efectivos de difusión 107

Cyclical time 116, 117, 125, 130

D

Diagnóstico experimental 46, 47

Digitalização agrícola 92, 104

Dry weight of roots 60, 64, 65, 66

Dry weight of shoot 60, 64, 65, 66

E

Electro-neumática 7, 8, 12

Electrónica Industrial 7, 8, 20

Espécie espontânea 69, 72, 80, 83

Espécie espontânea da caatinga 83

Eternal present 116, 117, 118, 121, 125, 130, 131

Ética 1, 3, 4

G

Geometría cilíndrica 21

Granger causality 138, 148, 150

H

Hordeum vulgare L. 60, 61

Humedad relativa 31, 35, 36, 37, 39, 40, 41

I

Ingeniería industrial 7, 8, 9, 10, 11, 14, 15, 17, 19, 20

Irrevocable sadness 116, 120, 121, 122, 124, 130

J

Japanese basic vocabulary 138, 139, 140

L

Linguistic rhythm 138, 157

M

Modelo cilíndrico 107, 110, 111

Modelos de combustibles 31, 33, 34, 35, 36, 38, 41, 42

MOOCs 92, 93, 95, 96, 97, 98, 99, 100, 101, 102, 104, 105, 106

N

Nanomedicina 1, 2, 3, 4, 5, 6

P

PLC 7, 8, 9, 14, 15, 16, 17, 18, 19, 20

Produção orgânica 69, 79, 90

Propagación en materia 21

R

Radiación electromagnética 21

Regiões áridas 46, 47

S

Sensores 2, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 92, 93, 94, 95, 97, 98, 101

Social synchronization 138, 157

Sociedad 1, 2, 4, 5, 6

Symbolic numerology 116

T

The invisible 116, 117, 120, 121, 122, 130, 131

Transferencia de masa 107

Triticosecale Wittmack 60, 61

Triticum aestivum L. 60, 61

Twitter/X 138

V

Verbally unexpressed absence 116, 120, 131

Z

Zanahoria 107, 109, 110, 111, 113, 114, 115