WEED SCIENCE





WEED SCIENCE

Published six times a year by the Weed Science Society of America

William K. Vencill, Editor

The Weed Science Society of America publishes original research and scholarship in the form of peer-reviewed articles in three international journals. Weed Science is focused on understanding "why" phenomena occur in agricultural crops. As such, it focuses on fundamental research directly related to all aspects of weed science in agricultural systems. Weed Technology focuses on understanding "how" weeds are managed. As such, it is focused on more applied aspects concerning the management of weeds in agricultural systems. Invasive Plant Science and Management is a broad-based journal that focuses not only on fundamental and applied research on invasive plant biology, ecology, management, and restoration of invaded non-crop areas, but also on the many other aspects relevant to invasive species, including educational activities, policy issues, and case study reports. Topics for Weed Science include the biology and ecology of weeds in agricultural, forestry, aquatic, turf, recreational, rights-of-ways, and other settings; genetics of weeds and herbicide resistance; chemistry, biochemistry, physiology and molecular action of herbicides and plant growth regulators used to manage undesirable vegetation, and herbicide resistance; ecology of cropping and non-cropping systems as it relates to weed management; biological and ecological aspects of weed control tools including biological agents, herbicide resistant crops, etc.; effects of weed management on soil, air, and water. Symposia papers and reviews are accepted. Consult the editor for additional information.

Associate Editors (Assignment Year)

Muthukumar V Bagavathiannan, Texas A&M, College Station, TX 77843 (2015)

Carlene Chase, Horticultural Sciences Department, University of Florida, Gainesville, FL 32611 (2016)

Bhagirath Singh Chauhan, Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland, Australia (2014)

Sharon Clay, South Dakota State University Plant Science Department, Brookings, SD 57007 (2002)

Adam Davis, USDA-ARS, Global Change and Photosynthesis Research, Urbana, IL 61801 (2007)

Franck E. Dayan, USDA-ARS-NPURU, National Center for Natural Products Research, University, MS 38677 (2003)

Anita Dille, Kansas State University, Department of Agronomy, Manhattan, KS 66506 (2013)

Timothy Grey, Department of Crop and Soil Science, University of Georgia, Tifton, GA 31793 (2009)

Marie Jasieniuk, Department of Plant Sciences, University of California, Davis, CA 95616 (2016)

Prashant Jha, Montana State University, Bozeman, MT 59717 (2017)

Ramon Leon, West Florida Research and Education Center, University of Florida, Jay, FL 32565 (2016)

John L. Lindquist, Department of Agronomy, University of Nebraska, Lincoln, NE 68583-0817 (2002)

Vijay Nandula, Mississippi State University, Delta Research & Extension Center, Stoneville, MS 38776 (2008)

Chris Preston, Australian Weed Management, University of Adelaide, PMB1, Glen Osmond, SA 5064, Australia (2003)

Neha Rana, Monsanto, Chesterfield, MO 63005 (2017)

Dean Riechers, Department of Crop Sciences, University of Illinois, Urbana, IL 61801 (2011)

Hilary Sandler, University of Massachusetts-Amherst Cranberry Station, East Wareham, MA 02538 (2008)

Steven Seefeldt, USDA-ARS, University of Alaska, Fairbanks, AK 99775 (2011)

Patrick J. Tranel, Department of Crop Sciences, University of Illinois, 360 ERML, Urbana, IL 61801 (2002)

Martin M. Williams II, USDA-ARS Global Change and Photosynthesis Research, Urbana, IL 61801 (2008)

Tracy Candelaria, Managing Editor

Officers of the Weed Science Society of America

Janis McFarland, *President*Scott Senseman, *President-Elect*Hilary Sandler, *Secretary*Rick Boydston, *Treasurer*

Larry Steckel, Vice President Sarah Ward, Director of Publications

Kevin Bradley, Past President Mark Bernards, Chair, Constitution and Operating Procedures

Weed Science (ISSN 0043-1745) is an official publication of the Weed Science Society of America, 12011 Tejon Street, Suite 700, Westminster, CO 80234 (720-977-7940). It contains refereed papers describing the results of research that elucidates the nature of phenomena relating to all aspects of weeds and their control. It is published bimonthly, one volume per year, six issues per year beginning in January.

Membership includes online access to *Weed Science, Weed Technology, Invasive Plant Science and Management*, and the online *WSSA Newsletter*. Dues should be sent to WSSA, 12011 Tejon Street, Suite 700, Westminster, CO 80234 no later than December 1 of each year. Membership in the society is on a calendar-year basis only.

New subscriptions and renewals begin with the first issue of the current volume. Please visit the *Weed Science* subscription page at https://www.cambridge.org/core/journals/weed-science/subscribe; Email: subscriptions_newyork@cambridge.org in USA, journals@cambridge.org outside USA.

Weed Science publishes six times a year in January, March, May, July, September, and November. Annual institutional electronic subscription rates: US \$411.00; UK £285.00; EUR €376.00.

Please use Editorial Manager to access manuscript submissions (http://www.editorialmanager.com/ws). Authors are asked to pay \$65 per page as a portion of the cost of publication, plus an additional processing charge of \$55 per manuscript if none of the authors are WSSA members. The Editor can make exceptions in advance when justified.

The Weed Science Society of America fully subscribes to the belief that progress in science depends upon the sharing of ideas, information, and materials among qualified investigators. Authors of papers published in *Weed Science* are therefore encouraged, whenever practicable and when state and federal laws permit, to share genotypically unique, propagative materials they might possess with other workers in the area who request such materials for the purpose of scientific research.

Weed Science published by the Weed Science Society of America.
Copyright 2017 by the Weed Science Society of America.
All rights reserved. Reproduction in part or whole prohibited.

On the Cover

Field photograph from Crespo et al. (Pp 743-754) of 2,4-D-resistant waterhemp from Nebraska. Photo credit: Roberto J. Crespo.



Volume 65 Number 6 November-December 2017

PHYSIOLOGY/CHEMISTRY/BIOCHEMISTRY

Target Site–Based and Non–Target Site Based Resistance to ALS Inhibitors in Palmer Amaranth (Amaranthus palmeri). Sridevi Nakka, Curtis R. Thompson, Dallas E. Peterson, and Mithila Jugulam	681
First Case of Multiple Resistance to Glyphosate and PPO-inhibiting Herbicides in Rigid Ryegrass (Lolium rigidum) in Spain. Pablo Tomas Fernandez-Moreno, Antonia Maria Rojano-Delgado, Julio Menendez, and Rafael De Prado	690
Distribution of Herbicide-Resistant Giant Ragweed (<i>Ambrosia trifida</i>) in Indiana and Characterization of Distinct Glyphosate-Resistant Biotypes. <i>Nick T. Harre, Haozhen Nie, Renae R. Robertson, William G. Johnson, Stephen C. Weller, and Bryan G. Young.</i>	699
Mechanism of Fenoxaprop- <i>P</i> -ethyl Resistance in Italian Ryegrass (<i>Lolium perenne</i> ssp. <i>multiflorum</i>) from China. <i>Pei Zhang, Han Wu, Hongle Xu, Yuan Gao, Wei Zhang, and Liyao Dong</i>	710
WEED BIOLOGY AND ECOLOGY	
Frequency of Gly-210 Deletion Mutation among Protoporphyrinogen Oxidase Inhibitor–Resistant Palmer Amaranth (<i>Amaranthus palmeri</i>) Populations. <i>Reiofeli A. Salas-Perez, Nilda R. Burgos, Gulab Rangani, Shilpa Singh, Joao Paulo Refatti, Leonard Piveta, Patrick J. Tranel, Andy Mauromoustakos, and Robert C. Scott</i>	718
Seed Germination and Seedling Emergence of Blackgrass (<i>Alopecurus myosuroides</i>) as Affected by Non-Target-Site Herbicide Resistance. <i>Eshagh Keshtkar, Solvejg K. Mathiassen, Roland Beffa, and Per Kudsk</i>	732
Multiple-Herbicide Resistance in a 2,4-D–Resistant Waterhemp (<i>Amaranthus tuberculatus</i>) Population from Nebraska. <i>Roberto J. Crespo, Ana B. Wingeyer, Greg R. Kruger, Chance W. Riggins, Patrick J. Tranel, and Mark L. Bernards</i>	743
Biology and Management of Glyphosate-Resistant and Glyphosate-Susceptible Palmer Amaranth (<i>Amaranthus palmeri</i>) Phenotypes from a Segregating Population. <i>Sushila Chaudhari, David L. Jordan, Alan C. York, Katherine M. Jennings, Charles W. Cahoon, Aman Chandi, and Matthew D. Inman</i>	755
Suitability of Wild Oat (<i>Avena fatua</i>), False Cleavers (<i>Galium spurium</i>), and Volunteer Canola (<i>Brassica napus</i>) for Harvest Weed Seed Control in Western Canada. <i>Breanne D. Tidemann</i> , <i>Linda M. Hall, K. Neil Harker, Hugh J. Beckie, Eric N. Johnson, and F. Craig Stevenson</i>	769
WEED MANAGEMENT	
Developing an Integrated Weed Management System for Herbicide-Resistant Weeds Using Lentil (Lens culinaris) as a Model Crop. Colleen Redlick, Lena D. Syrovy, Hema S. N. Duddu, Dilshan Benaragama, Eric N. Johnson, Christian J. Willenborg, and Steven J. Shirtliffe	778
Variable Tolerance among Palmer Amaranth (<i>Amaranthus palmeri</i>) Biotypes to Glyphosate, 2,4-D Amine, and Premix Formulation of Glyphosate plus 2,4-D Choline (Enlist Duo®) Herbicide. <i>Douglas J. Spaunhorst and William G. Johnson</i>	787
SPECIAL TOPICS	
Performance of Newly Developed Weed-Competitive Rice Cultivars under Lowland and Upland Weedy Conditions. <i>Niña Gracel B. Dimaano, Jauhar Ali, Pompe C. Sta. Cruz, Aurora M. Baltazar, Maria Genaleen Q. Diaz, Bart L. Acero Jr., and Zhikang Li</i>	798