Precision, Times Two.

Achieva Precision Table Top Germinator
• Save Space and Money
• Small Volumes, Precise Results
• Single Set-point Temperature Setting
• Digital Display of Set-point and Actual Cabinet Temperature
• Excellent Refraction

Ergostation Seed Inspection Station
• Increase Productivity
• Less Operator Fatigue
• Comfortable Streamline Process
• Avoid Costly Neck, Back and Wrist Pain
• Independently Adjustable for Right and Left Arms

Seedburo Equipment Co. has delivered industry-best testing, inspection and grading equipment to the grain, feed and seed industries for over 100 years.

Times have changed, and so has Seedburo. We have grown to offer the most technologically advanced seed analyzers in the industry. Key to customer needs, these tools are easy to use with broad capabilities.

Pick up your precision partner today, and always have an ally at your fingertips.

Seedburo
800-284-5779 | 312-738-3700
sales@seedburo.com | www.seedburo.com
Seed Technology

This journal is co-sponsored by the two predominant organizations in North America with a direct interest in seed technology: the Association of Official Seed Analysts and the Society of Commercial Seed Technologists.

Associate Editors:
- Samuel Contreras, Pontificia Universidad Catolica de Chile, Santiago, Chile
- Robert L. Geneve, University of Kentucky, Lexington, KY, USA
- Gwen Koning, Syngenta Crop Protection, Basel, Switzerland
- Deborah Meyer, California State Seed Laboratory, Sacramento, CA, USA
- Gary V. Munkvold, Seed Science Center, Iowa State University, Ames, Iowa, USA
- Jennifer Neudorf, Canadian Food Inspection Agency, Saskatchewan, Canada
- Amanda Patin, SGS Mid-West Seed Services, Inc., Brookings, SD, USA
- Robert Price, California State Seed Laboratory, Sacramento, CA, USA
- Richard Vierling, National Corn Growers Association, St. Louis, MO, USA
- Greg Welbaum, Virginia Tech, Blacksburg, VA, USA
- Yujia Wu, USDA AMS Seed Regulatory and Testing Branch, Gastonia, NC, USA

Aims and Scope – Seed Technology is an international journal containing scientific and technological papers in all areas of Seed Science and Technology. The emphasis is on applied and basic research in seed physiology, pathology and biology that may relate to seed development, maturation, germination, dormancy and deterioration. Studies on seed production, sampling, testing, conditioning, distribution and storage are also included. Short communications from seed analysts and technologists are encouraged and will be published as Seed Tech Notes. These notes include new techniques, standardization of laboratory tests and documentation of anatomical and pathological observations of seed and seedling development. The journal also includes timely review articles of seed technology that may relate directly to the seed industry.

Types of Papers – Original research papers, review articles and Seed Tech Notes are reviewed for publication. All manuscripts should be submitted online. Potential authors should note that there are no page charges and reprints can be ordered directly from the printer at a minimal fee. Refer to the last pages of this volume (Instructions to Authors) for detailed instructions regarding manuscript submissions.

Subscriptions – Seed Technology is published two times annually. The 2016 subscription price for print copies is $135.00 for individuals and $235.00 for institutions. An online subscription through the Seed Technology website (www.stjournal.org) with access to all past content is $125.00 for individuals and $225.00 for institutions. Subscriptions to the website with a print copy are $150.00 for individuals and $250.00 for institutions. All subscription prices with a print copy are in US dollars and include postage. Additional subscription options are available for libraries and other large organizations that require access through multiple accounts.

More information and subscription orders can be placed through the website, www.stjournal.org, or through the SCST Business Office at 653 Constitution Ave. NE, Washington D.C. 20002, USA.
EDITORIAL

The present volume includes seven full-length manuscripts and two Seed Tech Notes, as well as abstracts from oral and poster presentations at the 103rd AOSA/SCST annual meeting. Seed Technology continues to attract a diversity of authors addressing various issues related to seed science and technology. Articles in this issue range in subject matter from methods of improving germination, establishment and production of specific crops, to physiology of germination, seed analysis surveys and seed testing apparatus. To authors all around the world, Seed Technology remains an accessible means to publish and share quality articles related to seed science. Seed Technology is committed to publishing applied and basic research in all areas of seed science, such as seed technology, physiology, production, pathology and biology. We invite researchers interested in writing a review on one of those topics to contact the editors with their proposals.

The editors acknowledge the continued support by the Journal Committee, and its commitment to publishing two issues of the journal every year. The editors also wish to recognize our many associate editors and peer reviewers for their work on the many articles of this volume. The support of our two sponsoring organizations, the Association of Official Seed Analysts and the Society of Commercial Seed Technologists, is appreciated.

Branched (Orobanche ramosa L.) and Egyptian (Orobanche aegyptiaca Pers.) broomrapes, like many other phanerogamic parasites, challenge our concepts of seed vigor. Parasitic broomrape seeds develop by absorbing host plant synthates shortly after germination. Seed vigor attributes such as emergence speed and stress tolerance are therefore of minor relevance for such species. The “vigor” of Egyptian (left) and branched (right) broomrape seeds is better understood as a function of small size, dispersal potential and soil longevity, seed-based attributes commonly used to describe highly invasive and persistent weed populations. Scale line = 0.5 mm. Photo credit: Vivian Le and Riad Baalbaki, California Department of Food and Agriculture.
Friends of the Journal

**Platinum Supporters**
BioDiagnostics, Inc.
Indiana Crop Improvement Association
Phani Bangalore, Turf Tech, Inc.
Brenda Watts, Alforex Seeds

**Gold Supporters**
Sue Alvarez, US Agriseeds Laboratory
Harold Armstrong, Monsanto Seed Tech Center
Olga Maseda, Harris Moran Seed Co.
Seed Technology

Instructions to Authors

*Seed Technology* is an international journal that publishes original papers, review articles, technical notes and symposia in all areas of seed science and technology. This includes information from applied and basic seed research in physiology, pathology and biology for all plant species. The journal relates to individuals interested in seed production, sampling, testing, conditioning, distribution and storage of agronomic, horticultural and forest seed crops. Papers are accepted on the understanding that they have not been published or submitted to any other scientific journal. The criteria for acceptance are originality, quality of research and interest to readership. Manuscripts are peer-reviewed by two or more anonymous reviewers, with final acceptance resting with the Editorial Board. The journal is published two times per year and is available as paper copies by contacting: SCST Business Office, 653 Constitution Ave. NE, Washington, D.C. 20002, USA (phone: 202-870-2412). Subscription information and order forms are available online at: [http://www.stjournal.org](http://www.stjournal.org).

Manuscripts must be clearly written using proper English. If English is not the primary language of the author, the manuscript should be reviewed by someone proficient in English prior to submission to the journal. Manuscripts should be submitted online; see “Guidelines for Submission” at the end of the instructions. Five types of submissions will be considered for publication:

a. **Full-length manuscripts** should report new information to the subject area or expand on established knowledge to contribute additional information of value. Manuscripts undergo peer review to determine that adequate scientific methods were applied, that interpretations and conclusions are valid, and that all aspects of the study are adequately presented.

b. **Seed Tech Notes** are appropriate for the reporting of seed laboratory or seed production research that may not justify a full paper, but provide important information of potential practical importance. This may include new techniques or developments, standardization of old techniques or anatomical, pathological or other documentation of seed or seedling development. The requirements for such notes are described below.

c. **Technical Papers** presented orally or by poster at the annual meeting of the Association of Official Seed Analysts (AOSA) and Society of Commercial Seed Technologists (SCST) are invited, which cover topics of general interest to the seed biologist or technologist.

d. **Symposia** or workshops presented to the AOSA/SCST membership may be recorded in the journal for future reference. Organizers should prearrange with the Editor to receive papers from the presenters of symposia and workshops within a specified timeframe for inclusion in a single journal issue.

e. **Review articles** are welcomed by special prior arrangement with the Editor. Reviews should cover a summary of a seed biology or seed technology topic
or an evaluation of a seed science or technology related publication. The content of reviews should have a strong technical and/or scientific base.

INSTRUCTIONS FOR FULL LENGTH MANUSCRIPTS

Instructions for full length manuscripts should be carefully reviewed to ensure that the submitted manuscript complies with *Seed Technology* standards and requirements. If these guidelines are not closely adhered to, papers will be returned to authors for revision or released from further consideration for the journal.

Manuscripts should be arranged in the following order: Title (no separate title page), Author(s), Abstract, Text, Acknowledgments, References, Tables, Captions for Figures (separate page) and Figures. Do not include a list of keywords. The title should be concise (10 to 12 words) but informative, containing key words which describe the subject matter for use in abstracting systems. The name of the author(s) should be placed below the title with an asterisk (*) after the name of the corresponding author.

The abstract should concisely summarize the entire scope of the paper including findings and conclusions without reference to text or figures. All categories of manuscripts or papers submitted to the journal must have an abstract. It should appear immediately below the title and authors and consist of not more than 250 typed words. Authors may provide a translation of the abstract in one additional language, which will be printed in the journal following the primary abstract in English. Availability of abstracts in alternate languages should be discussed with the Editor early in the submission process. Accuracy in regard to content and grammar of the second abstract is the responsibility of the corresponding author. Do not include a list of key words.

The text of the manuscript should normally have the subject matter grouped under the following major headings: Introduction, Materials and Methods, Results, Discussion (Results and Discussion may be combined), Acknowledgments (optional) and References. Main headings are centered on each page and capitalized in bold type. Secondary headings begin at the left margin (do not indent) with the first letter capitalized and the entire heading in bold print. Use of a previous issue of the journal as a guide to format is recommended.

Author-Paper Documentation. Author-paper documentation is a single paragraph at the bottom of the first page (under abstract). The first sentence lists the authors (without professional titles) and their complete addresses. If the author has moved, provide the current address. Always end the author-paper documentation with: *Corresponding author (e-mail address of corresponding author). Received __________.

Style Manual. Scientific Style and Format: The CBE Manual for Authors, Editors, and Publishers, 6th edition, prepared by the Style Manual Committee of the Council of Biology Editors and published by the Cambridge University Press should be followed for writing papers submitted to *Seed Technology*. The Publications Handbook and Style Manual of the American Society of Agronomy can also be used as a detailed guide for both paper and electronic manuscript preparation and can be accessed online at
**Abbreviations.** Use standard abbreviations (for example, Fig., RH, °C) listed in *Scientific Style and Format*, SI units and chemical element symbols without definition. Other abbreviations should be defined at first usage in the abstract or text and may be used thereafter without further definition, and again in every table and figure. Names of states, provinces and countries should be abbreviated following city names, using appropriate abbreviations of the postal service in that country.

**Units.** Metric units must be used for all measurements and the SI system (Système International d’Unités) used insofar as possible.

**Numbers.** Use Arabic numerals for all numbers with two or more digits and for all numbers that appear in conjunction with units of measurement, except when the number is the first word in a sentence. Spell out numbers when they are the first word in a sentence or when they are a single numeral from one to nine and not measurements, except when in a series in which one figure has two or more digits. Decimals should be expressed using a period (5.05, for example). The percentage sign should be used in conjunction with a number (5%), but percentage should be written in full when used as a noun (germination percentage). Dates should be given as 2 December, 1998, for example.

**Nomenclature.** Species should be described by their scientific (Latin) names. At first mention in the main text the full binomial and authority must be given, but subsequently the genus should be abbreviated to its initial letter and the authority omitted. Authorities are not quoted after Latin names in the title or abstract. At first mention, crop varieties should be identified by single quotation marks, for example, ‘Ranger’ alfalfa (*Medicago sativa* L.)

**Experimental Design and Data Analyses.** Enough details of experimental conduct and design should be reported for readers to judge the validity of results. Treatment details, number and type of experimental units, factor levels, experimental layout, number of replications, and how measurements were made should be sufficiently described whenever appropriate. A measure of precision, usually standard error of treatment means, should be included with all data. Mean separation procedures should not be misused and authors should be aware of the limitations to the use of multiple comparisons. Treatment comparisons are appropriate when the relevant F value is significant, but should be avoided when treatments have a logical structure, as in factorial designs. In that case, the use of orthogonal contrasts is appropriate.

**Tables.** Tables should be numbered consecutively with Arabic numbers and should be reduced to the simplest form. Each table should be typed on a separate page from the main text. Table headings should be brief but complete and self-contained. Any explanation essential to the understanding of the table should be provided as a footnote at the bottom of the table. Use the following symbols for footnotes, in this order: †, ‡, §, ¶, #. Asterisks are used only to indicate statistical significance, with * and ** representing significance at the 0.05 and 0.01 probability levels, respectively. Do not duplicate table information in figures.
Figures. All electronic images should be submitted in their native, highest possible resolution file format without insertion into a .DOC or text file, such as MS Word or WordPerfect. This is necessary because any graphic files embedded into a text file must be extracted for use with layout software during typesetting. Graphic files extracted from a text file are not as usable as the form they were in before insertion. Examples of acceptable graphic file types would be .TIF, .JPG, .BMP and .EPS. Images should be high resolution without compression. Photographs should only be submitted if they are essential for understanding the manuscript. All figures should be of sufficient size and quality to allow for reduction by half or more for printing. Lettering should be kept at a minimum in graphs. All lettering, symbols and lines must be large enough, clear enough and thick enough to still be easily read and prominent after reduction. Preferred symbols for line art figures are black and white open and closed squares, circles and triangles. Do not use colors, shades of gray, or fine screens or patterns to fill bars on graphs or wedges on pie charts. Use solid black or white, well-spaced parallel lines, widely spaced dots, or other black and white line art methods. Any patterns and lines should be able to withstand reduction by half or more. Figure captions should be brief, self contained and listed consecutively on a separate sheet at the end of the manuscript.

Acknowledgments. This section lists institutional sponsors with identification of the research project including granting agency recognition, if appropriate. This segment can also be used to thank anyone who was instrumental in or contributed to the completion of this study.

References. The author-year notation should be used in the text. Citations by authors in the text should appear as Smith (1996) or (Smith, 1996). Use “et al.” each time when there are three or more authors for a reference in the text, but give all authors in the reference list itself. In the reference list, arrange all published citations alphabetically by author: for example, last name and then initials of the first author, with each subsequent author listing arranged with first name initials first and then last name. Citations should include names of all authors, year, complete title, abbreviated journal title, volume number and inclusive pages. Cite personal communication and unpublished work only in the text, not in the reference list. Examples of acceptable references are:


It is always preferred for papers to have references, but some papers based on presentations or workshops may be acceptable without them by prior arrangement with the Editor.

Proofs, publication charges and reprints. One set of page proofs in Adobe Acrobat format will be returned to the corresponding author. Corrections should be restricted to printer’s errors and returned to the Editor promptly.

Seed Technology does not require page charges. Authors can order reprints, either as hard copies or an electronic copy (PDF), directly from the publisher when returning corrected proofs. For more information on ordering single articles, past issues and order forms, please contact the Editor or Assistant Editor, or go to http://www.seedtechnology.net/journal.htm.

GUIDELINES FOR SUBMISSION

All manuscripts should be submitted online (http://scst.expressacademic.org/login.php). New users should first register before logging in. Once logged in, the website will prompt authors through the process. The manuscript should be double spaced with ample margins, line numbers, and numbered pages. Macintosh and Windows versions of MS Word or WordPerfect may be used for submission. Files can also be accepted in MS-Works, RTF, ASCII and other formats if the preferred options are not available.

Address all inquiries to the Editor or Assistant Editor:

Riad Baalbaki, Editor
Senior Seed Botanist
California Department of Food and Agriculture
Plant Pest Diagnostics Branch
3294 Meadowview Road
Sacramento, CA 95832-1448
Phone: (916) 262-3292
Fax: (916) 262-1190

Susan Alvarez, Assistant Editor
Registered Seed Technologist
Laboratory Manager
Ransom Seed Laboratory
P.O. Box 300
Carpinteria, CA 93014-0300
Phone: (805) 684-3427
Fax: (805) 684-4157

INSTRUCTIONS FOR SEED TECH NOTES, TECHNICAL PAPERS AND SYMPOISA OR WORKSHOPS

The format for Seed Tech Notes, technical papers and presentations from symposia or workshops is as for full length papers insofar as practical. The text headings may be the same as a full paper or may be arranged by Abstract, Experimental Techniques, Results and Discussion, and References, if that format is more suitable to the presentation of the material. The Experimental Techniques section will include a brief narrative of those elements normally included in the Introduction and Materials and Methods sections of full length papers. Seed Tech Notes and technical papers are usually much shorter and may present only preliminary research data compared to full length papers. These papers usually do not exceed four pages of printed text and a maximum of two figures, tables or photographs. Papers presented at committee meetings, symposia and workshops not containing cited references or other conventional journal paper elements may be considered for publication if these presentations
contain information of a practical nature or general interest in seed biology and technology.

**SYMPOSIA PUBLICATIONS**

Manuscripts resulting from symposia on seed biology or technology topics will be considered for publication in a single volume of *Seed Technology* by prearrangement with the Editor. Manuscripts may originate from symposia sponsored by the Association of Official Seed Analysts or the Society of Commercial Seed Technologists or from appropriate seed symposia sponsored by other organizations. Symposia organizers desiring to publish a set of manuscripts in *Seed Technology* must solicit the Editor with the following information: (i) title, date and location of the symposium, (ii) the organization affiliated with the symposium, (iii) names, addresses, e-mail and telephone numbers of symposium organizers and (iv) titles and abstracts for each paper to be considered for publication. Symposia papers are subject to the usual format described above for *Seed Technology* and will be reviewed by the editorial board prior to acceptance for publication.
FULL-LENGTH PAPERS

Catalase and Peroxidase Activities and Acquisition of Desiccation Tolerance in Hybrid Maize Seed / Enayat Rezvani, Farshid Ghaderi-Far, Aidin Hamidi and Elias Soltani ............... 119

Storage Environment Effects on Soybean Seed Emergence and Estimated Cost of Production / Michael Popp, Elijah Wolfe, Ed Gbur, John Rupe, Craig Rothrock, Kimberly Cochran and Adele Steger. ....... 137

Determination of Optimal Seed Harvest Timing for Panicum torridum Based on Growing Degree Day Heat Unit Accumulation / Scott B. Lukas, Joseph DeFrank and Orville C. Baldos. ................. 151

Upgrading Seed Quality of Ryegrass Using a Blowing Procedure / Gadotti, Sabry Elias and Adriel Garay. ....................... 161

SEED TECH NOTES

Delayed Nitrogen Application Influence on Production and Physiological Potential of Soybean Seeds / Larisse Pinheiro Schmid, Carla Michele da Silva, João Carlos Medeiros and Fabio Mielezrski. .... 175

Color as Maturation Indicator for Maximum Seed Quality of Sterculia urens / Maitreyee Kundu and Shilpee Singh. ................. 185

ABSTRACTS from oral and poster presentations at the 2016 AOSA/SCST MEETING, Portland, Oregon

Seed Identification from ITS DNA Sequencing / Robert Price. ... 197

Forages: the Seeds of Sustainability / David B. Hannaway. ......... 198

Instructions to Authors. ..................................................... 199