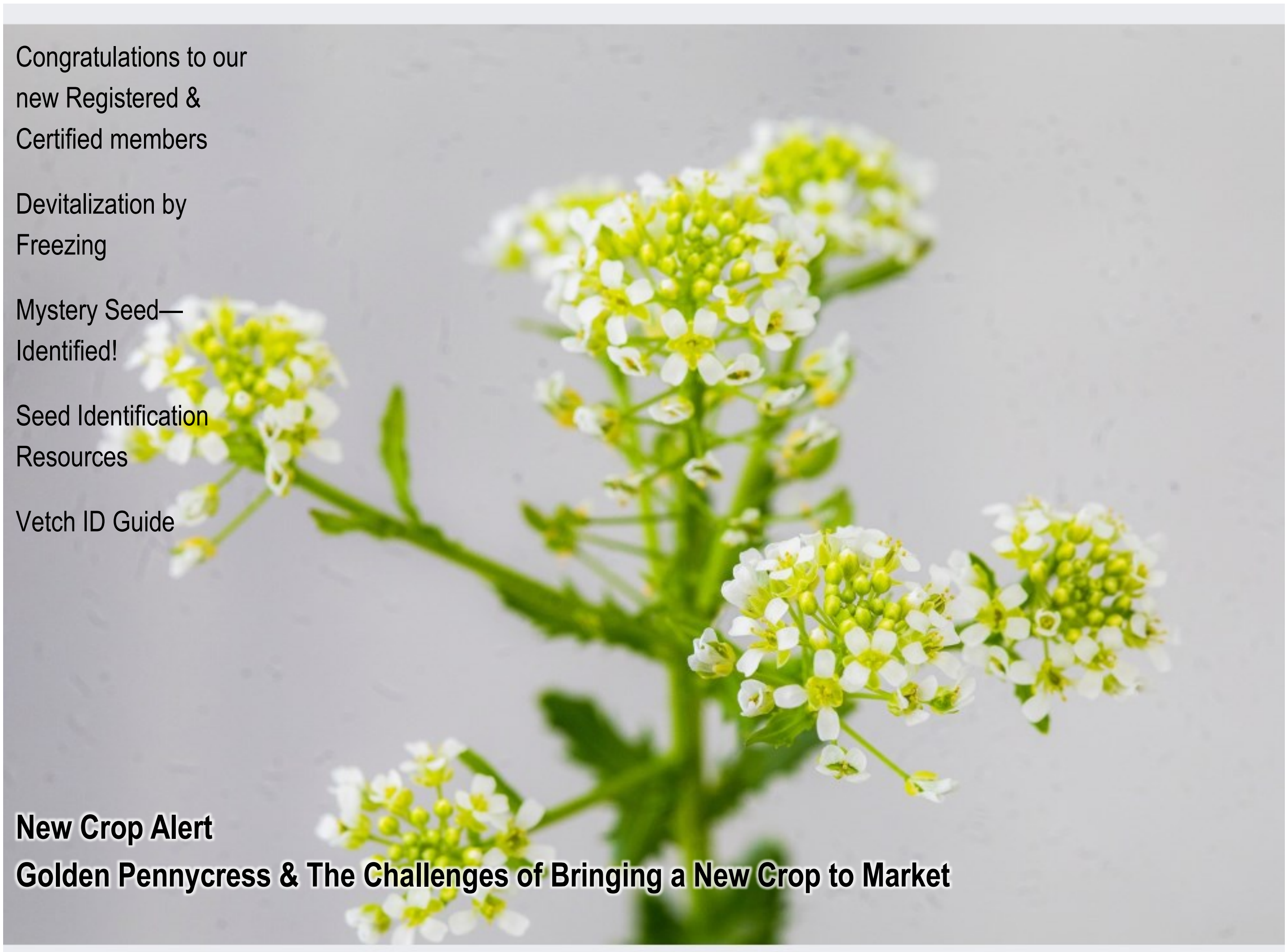
The Seed Technologist Newsletter

A newsletter for members of AOSA-SCST

Volume 91 No. 2
November, 2024



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The Seed Technologist Newsletter

A newsletter for
The Association of Official Seed Analysts
and
The Society of Commercial Seed Technologists

Volume 91, Issue 2
November, 2024

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Elisabeth Wood, CVT

Newsletter Submission Guidelines

Articles should be typed, pertaining to some aspect of seed testing or other items of interest to the AOSA and SCST membership. These may include, but are not limited to:

Ongoing research
Committee and Working Group activity
Updates on the financial state of the organizations
Distinguished member profiles
Profiles of new members to the organizations
Research paper abstracts
Results of research, referees, and validation studies
Upcoming changes to the AOSA Rules
Upcoming changes to the By-Laws of the organizations
Survey study results
Information from other seed-trade organizations
Regional updates to state seed laws or RUSSL
Information on upcoming workshops or other opportunities for training
Book and resource reviews
Impressions from the Annual Meeting

Formatting:

Please include images as **separate** files, with credit to the photographer if different than the author. All images used will be credited.

For specific formatting within a document, please do not insert images, but leave a placeholder so that the editorial staff can include appropriate images, graphics, and tables within articles.

Please do not submit PDFs of articles.

Citations:

Cite image sources and references used in APA7 style.

Cite any additional sources used to compose the article, including co-authors so that they may be credited.

Author’s name and contact information to be included in our contributor’s page.

Publications must be in accordance with the Anti-trust policy of the AOSA- SCST.

Calendar of Events

November

ISSS-ISTA Webinar on Seed Supply — Free Virtual Webinar
November 27, 2024

December

ASTA's Field Crop Seed Convention — Orlando, FL
December 10-13, 2024

ISTA Online Workshop on Quality Assurance and ISTA Accreditation — Virtual Workshop
December 16-18, 2024

January

Oregon Seed Association—Mid-Winter Meeting — Lebanon, OR
January 15th-16th, 2025

ASTA's 64th Vegetable & Flower Seed Conference — Orlando, FL
January 31, 2025 - February 4, 2025

February

SCST—RGT Exam — SGS
February 4, 2025 9:00am — Brookings, SD

Iowa Seed Forum — Altoona, IA
February 12, 2024

2025 National Native Seed Conference — Tucson, AZ
February 24-27, 2025

March

Newsletter Submission Deadline — Please submit articles to the Communications & Publications Committee Chairs
March 31, 2024

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Editorial

Quinn Gillespie, SCST Editor

Here in Oregon, we have been in the midst of another busy harvest season, this year with an extra splash of fall color. For most of us, this is when we spend the majority of the time with our noses to our purity boards and forceps in hand. It's the time of year when it's easiest to push additional research projects to the back burner, in order to simply get through the day's tests. And while it can feel like our ongoing research is in hibernation, the gears are still turning behind the scenes.

Referee projects are ongoing, researchers are drafting their papers and preparing studies for next year. We had great participation in the Buzz session, and discussion about how to solve some of the problems facing seed production and regulation. Many of the projects discussed are well underway.

Work on the Analyzeseeds portal is moving ahead. The programming team is focusing on streamlining the registration process for the annual meeting to make it as smooth as possible—as soon as possible.

The Board of Examiners is continuing to work toward offering the exam online. There are a few more trainings to take place this winter, and new photos to take for the germination portion, but progress is moving forward.

Analysts representing AOSA-SCST will be attending the 2025 National Native Seed Conference, and the boards have worked to design magnets advertising AOSA & SCST for attendees to take home with them.

Planning meetings for next year's Annual Meeting are happening, with folks bringing their ideas to the table. There's a passionate group of members working to put together an agenda which should be informative and enjoyable. As a kid in the Midwest, every summer my family would drive from Iowa to Washington state to visit family, and Missoula was a perennial stop on our way. Downtown is divided by the Clark Fork River and boasts plenty to do in the evenings, with restaurants, art galleries, and a natural history center. There are four nearby parks, including a carousel, featuring hand-crafted wooden horses and other creatures.

So- like seeds, while we all have our heads down, busy with the daily tasks of laboratory testing and the movement of seed, our organizational activities continue, working to move us forward in research, education, outreach, and collaboration. I look forward to seeing everyone in Missoula this June!

AOSA SCST 2025 Annual Meeting

Missoula, Montana

June 8-12, 2025

See you in Missoula! June 2025

Check for updates at: https://analyzeseeds.com/annual-meetings/

Hotel Address & Contact:

200 South Pattee
Missoula, MT 59802
Front Desk: (406)-721-8550
Email: guest.service@himissoula.com

Hotel Information

- Complimentary shuttle to and from any destination within the Missoula City Limits, as well as to and from the Missoula Airport
- $197.00/night + taxes/fees; Per Diem rates
- Complimentary Self-Parking
- Complimentary WiFi in Meeting Rooms and Guest Rooms
- Located near Clark Fork River, parks, and walkable to downtown Missoula

What's Happening at ASTA

Kaitlin Crawford, Director, Marketing & Communications, ASTA

Meetings and Events

If you're looking for ways to engage with the broader seed industry, ASTA offers several large events targeting various sectors of the industry each year.

Upcoming Dates:

- Field Crop Seed Convention: December 10 – 13, 2024 | Orlando, Florida | Register Here
- Vegetable & Flower Seed Conference: January 31 – February 4, 2025 | Orlando Florida | Register Here
- Leadership Summit: June 7 – 11, 2025 | Washington, D.C. | Find Out More Here

At the start of the year, ASTA's **Vegetable & Flower Seed Conference** brings together over 1,000 vegetable and flower seed producers and service providers from over 30 countries. This conference features leading industry, academic, and government speakers on a range of topics from organic production to plant breeding innovation and more. The Trading Room, a focal point of the conference, is the networking hub of conference activity, with all-day networking and global business opportunities.

In June, the ASTA **Leadership Summit** brings together all sectors of the seed industry. This event has been reinvented to focus on advancing policy initiatives while developing future leaders. Sessions cover a variety of topics from plant breeding innovation, domestic and international policy and communications to leadership and management skills. Next year's meeting will be unique as it will be held in Washington, D.C. after an epic election season, and will feature an Advocacy Day, where participants will have the opportunity to lobby on Capitol Hill, educating members of Congress on the seed industry's priorities.

In the fall, ASTA's **Forage, Turf, & Conservation Seed Conference** joins up with the Western Seed Association's Annual Meeting for a day of programming and networking. A morning general session and ASTA committee meetings feature timely speakers in various roles, from government, regulatory, and industry experts.

Closing out the year, ASTA's **Field Crop Seed Convention** is held annually in early December. Approximately 2,000 attendees, focusing on field crops in the Midwestern United States, are presented with the latest updates on key seed industry issues and an unparalleled sales and marketing opportunity. Topics include the global ag economy, seed treatment, plant breeding innovation, phytosanitary issues, intellectual property rights, cover crops, and more.

To learn more about these events and ways to get involved, visit www.betterseed.org/asta-events/.

Staff Updates

Earlier this year, ASTA's Pat Miller was promoted to Senior Director, Special Projects, leading up to his eventual retirement at the end of 2024. Pat has led ASTA's state government affairs since 2007, working with state and regional industry associations to monitor legislative initiatives across the 50 state capitals, and managing legislative, regulatory, and grassroots activities in response.

In anticipation, ASTA's Jordan Gregory was promoted to Director, State Government Affairs in January 2024 and has hit the ground running, traveling across the country representing the seed industry at various events. Jordan has served as ASTA's Manager of Membership Engagement since 2021 and is well acclimated with our diverse membership and their needs. In this new role, she will lead ASTA's state government affairs advocacy efforts, ensuring that the seed industry continues to have a strong voice across the country.

Farm Bill Update

Every five years, Congress sets out to pass a new piece of legislation, the Farm Bill, which is an omnibus, multiyear law that governs an array of agricultural and food programs. We have been operating under a one-year extension to the 2018 Farm Bill, which expired September 30, 2024. The lapse of this legislation has a variety of impacts, including the expiration of particular programs, such as farm commodity support programs and key research authorities. While many programs won't be affected until the end of the year, Congress must either pass a new Farm Bill, or another extension to the current 2018 Farm Bill by December 31, 2024, to avoid significant disruptions to federal agriculture programs.

The likelihood for passage of a new Farm Bill by the end of the year remains unclear, as we have yet to see text and forward movement from Congress. In late May, the House Agriculture Committee passed the Farm, Food, and National Security Act of 2024, but the legislation has not been considered on the House Floor, and no legislation has been considered in the Senate.

ASTA has remained no stranger to lawmakers on Capitol Hill as we continue to advocate for issues of importance to the seed industry in the next Farm Bill. These policy priorities extend across a variety of Farm Bill titles, including policy priorities in the Conservation, Research, Trade and Horticulture titles. In addition to the ASTA Government Affairs team's efforts, Congress has heard directly ASTA members through a variety of channels, including through testimony at two Senate Agriculture Committee Farm Bill hearings, and through written testimony at a House Agriculture Committee's Conservation hearing. Additionally, ASTA was pleased to have language included in the House Committee passed legislation addressing concerns with EPA's final rule on Planet Incorporated Protectants.

OSA Spring Workshop & Professional Development

Submitted by the Oregon Seed Association

The 2024 OSA Spring Workshop & Professional Development Event is in the books and was nothing short of a success! Nearly 100 people attended one or more of the four days, featuring multiple educational seminars, and finishing with our Association's first-ever Forklift Rodeo putting drivers' skills to the test.

We look forward to bringing this event back next year and thank everyone for their participation! A special thanks also goes to our wonderful speakers, and to Chemeketa Community College for hosting us. It is encouraging to have such amazing support.

Six contestants saddled up for Friday's Forklift Rodeo, where they competed for best time on the obstacle course while demonstrating safety and finesse behind the wheel. Melesio Rodriguez of Pure Seed came out on top with a winning time of 2 minutes, 11 seconds. Rodriguez will be recognized during our upcoming Summer Convention in Bend.

Overall, this was a fun and unique way for our drivers to brush up on their skills and get certified or re-certified, if necessary. We hope to see more folks join us next year — when we will officially be able to say this is not our first rodeo!

Lab Input

The other three days featured presentations from speakers covering a variety of topics, including proper seed sampling techniques, testing requirements, and interpreting analysis reports. We also had great discussions on fluorescence, ethical reporting concerns, and the need for more education to better understand rules.

As a reminder to OSA members, please check out our Seed Testing Labs resource online. This is a great tool that shows the dates of samples received by our associate labs, with results for Purity, Noxious Weeds, Germination, Tetrazolium (TZ), Crop & Weed, and Sod.

It is important for our labs to keep this information posted and up to date. For companies, you can ensure quicker and more accurate results by keeping the following in mind:

- Labs appreciate (or require) having a written record when changes are requested on a test. Emails are preferred, versus a phone call.
- Do not write on seed tests. This is considered tampering with official documents. The number one offender of this is adjusting the weight — don't do it! Labs offer services to amend the quantity, or you can also leave it blank.
- Be mindful of "rush" requests. If labs get too many of these requests, it can make it difficult for them to prioritize what is most important.

If you have any questions, please contact Science & Technology Committee Chair Colin Scott at colin.scott@scotts.com, or Co-Chair Kristen Haskett at khaskett@siteone.com.

Seed Analyst Committee Holds Annual Meeting

Laura Donaldson, Illinois Seed Trade Analysts Committee Member

The Illinois Seed Trade Association's Seed Analyst Committee held its annual meeting on August 21st, with 19 participants from seven laboratories across the Midwest gathering at the AgReliant QA Lab in Brimfield, IL. The meeting focused on critical issues and developments in the seed industry, providing a platform for professionals to exchange insights and discuss future directions.

One of the primary discussion topics was the review of results from the annual referee tests on corn, soybeans, and sweetcorn. Participants engaged in a robust discussion about potential changes to these tests, including limiting the number of participants, adjusting the timing of the tests, and possibly removing the vigor test from the referee process.

In addition to the referee test review, attendees explored other significant issues in the industry, including soybean mechanical damage, the presence of adventitious material, bioassay methods, and seed identification techniques.

The meeting concluded with a tour of the AgReliant QA Lab, giving participants a firsthand look at the facility's operations. The Illinois Seed Trade Association extended special thanks to the AgReliant staff for their hospitality and hosting this important event.

For more information on how to participate in future events, visit analyzeseeds.com.

New Registered & Certified Members - Spring 2024

Consolidated Exam Committee

New RSTs

April Edin—Eurofins BioDiagnostics, Inc

Christopher Roberts—Corteva Agriscience

Elisabeth Wood—Syngenta Seeds, Nampa ID

Mike Madsen—SoDak Labs, Brookings, SD

Miranda Smidt—Applewood Seed Co.

New SCST CVTs

Brandie Taylor—ADM Edible Beans

Marissa Mech—Corteva Agriscience

Omar Elsharkawy—JG Boswell

Terrance Fox—Corteva

New AOSA CSA– Purity

Jenny K. Hall—GA Department of Agriculture

New AOSA CSAs—Germination

Tori Kloppenborg—USDA

Ashley Thomas—North Dakota State

New Registered & Certified Members - Fall 2024

Consolidated Exam Committee

New RSTs

Juan Ballesteros—WSDA Seed Program
Mark Berns—Illinois Crop Improvement Association
Lauren Bogi—Michigan Crop Improvement Association
Rachel Geary—Wyoming Seed Analysis Lab
Melissa Nelson—NST Labs
Maggie Risher—Bayer
Jolie Robinson—WSDA Seed Program
Alyssa Stevens—Harris Seeds

New SCST CVTs
Katlyn Hitz—Magnoseed
Hailey Osborne—Crookham
Kevin Przybyla —HM Clause
Anjelica Scheuermann—Corteva AgriScience
Sharmila Sunwar—Sakata Seeds

New AOSA CSA—Overall

Snjezana Dacic—Idaho Department of Agriculture
Elizabeth Geyer—Virginia Department of Agriculture & Consumer Services
Ella Greeley—Arkansas Department of Agriculture
Neelima Mareedu—Virginia Department of Agriculture & Consumer Services
Madeline Rivard—Maryland Department of Agriculture

New AOSA CSAs—Germination

Edward Barge—Idaho Department of Agriculture
Marquise Beckett—Maryland Department of Agriculture
Damaris Rodriguez—Florida Department of Agriculture & Consumer Services
Lori Swonke—Texas Department of Agriculture
Vincent Warnock—USDA ARS PA NLGRP
Angela Yau—Arizona Department of Agriculture

On behalf of your colleagues in AOSA & SCST

Congratulations to all our new Registered and Certified members!

SCST New Registered & Certified Member Profiles

As submitted by new RSTs, RGTs, CVTs, CPTs, CGTs

Marissa Mech, CVT

My name is Marissa Mech and I currently work for Corteva Agriscience. I have been a seed analyst for three years and thoroughly enjoy my job. I have always had a profound interest in plants and their physiology as well as a fascination with the intricate mechanisms of plant life and agriculture. I feel fortunate to have found a career where I get to work so closely with seeds.

I hold a Bachelor of Science Degree in Natural Resources and Environmental Management as well as a minor in Botany from Ball State University located in Muncie Indiana. With a solid academic foundation and hands-on experience in the laboratory, my journey has been defined by a commitment to understanding the pivotal role of seeds in global food security and sustainable agriculture. Through study and practical application, I have cultivated knowledge in seed science and hope to contribute to innovative solutions to modern agricultural challenges throughout my career. I obtained my CVT certification in April 2024 and hope to gain more certifications and knowledge in the future.

Elisabeth Wood, CVT

Elisabeth Wood joined the Syngenta Vegetables Seeds QC Physiology team in January 2021as the QC Physiology Operations lead. She manages a team of 17 outstanding individuals that complete towel germination, vigor and soil emergence testing. The team specializes in 18 different vegetable crops and complete quality testing for seeds produced around the world.

Elisabeth has over 15 years of plant science experience from sweet corn breeding, lettuce and spinach breeding, and plant pathology in potato diseases. She has a Bachelor of Science from Idaho State University and a Master of Science from the University of Idaho.

Elisabeth grew up in Idaho, in an agricultural community and gained a deep love and appreciation of plant science working in the garden with her father. She is doing her best to impart a love of nature in her two young children.

SCST New Registered & Certified Member Profiles

As submitted by new RSTs, RGTs, CVTs, CPTs, CGTs

Katlyn Hitz, CVT

Katlyn has 12 years' experience working in Agricultural research. She has a master's degree in plant and soil science with a focus on plant breeding and genetics. She spent 9 years working in breeding programs for small grains. 4 of those years were spent as a barley development scientist with MillerCoors where she managed their quality lab. She became a part of the sugar beet seed world when she joined Magno Seed in 2021 as the R&D site manager in Longmont, CO. She spent 2 years in this position until she began her new role in 2023 as the Head of Quality Assurance. Katlyn is very dedicated and passionate in her work. She brings values such as innovation, integrity, and teamwork to the seed industry.

Outside of work Katlyn enjoys all the outdoor activities Colorado has to offer. She is an avid runner who enjoys competing in races. She loves spending time with her two pups, cat, and chickens and enjoys having a beer or two with friends.

Maggie Risher, RST

I have been working at Bayer CropScience in Waterman, IL, as a Seed Analyst for 5 years. I am currently a member of the Editorial Working Group in the Communications & Publications Committee, and look forward to getting further involved with AOSA/SCST committees in the future. When I'm not looking at seeds and seedlings, I enjoy spending time with my cat, Aspen, reading, playing cozy video games, and traveling to the Pacific Northwest to spend time with family.

AOSA Certified Member Profiles

As submitted by new CSAs in Purity, Germination

Jenny Hall, CSA

Thank you to AOSA/SCST for a great Annual Meeting in Rapid City, South Dakota. I enjoyed meeting new people within the seed testing community and hearing more about the work each committee is doing. Also, thank you for the recognition of passing the Purity Exam and becoming a Certified Seed Analyst. Becoming a Certified Seed Analyst is a huge milestone for me in my career and it is a great honor to be a part of such a wonderful organization. Thank you for all you do, and I look forward to more Annual Meetings in the future.

Jenny Hall, CSA
Seed Lab Manager
Georgia Department of Agriculture
Tifton Seed Lab
Tifton, GA

Tori Kloppenborg, CSA—Germ

Torie Kloppenborg began working at the National Laboratory for Genetic Resource Preservation in Fort Collins, Colorado in 2022. Her main focus is developing and refining germination protocols for wild collected native species and monitoring samples in the national seed collection. Prior to moving to Colorado, she worked at the North Central Regional Plant Introduction Station in Ames, Iowa, where she assisted with seed regeneration, seed conditioning, and germination testing.

AOSA Certified Member Profiles

As submitted by new CSAs in Purity, Germination

Ella Greeley, CSA—Germ

I graduated from Henderson State University in the spring of 2022 with a Bachelor's degree in Natural Resource Management and a minor in Biology. In my free time, I love going on coffee trips, knitting, and reading. My summers are filled with hiking, fishing, and gardening. This past summer I had the opportunity of growing my first garden. I learned so much and am already making plans for the next one! Growing up, I enjoyed helping my mom with her flower beds, so when I saw a job listing for a seed analyst, I felt compelled to apply. The role turned out to be quite different from what I expected, but I truly enjoy the work. I began my position at the Arkansas Department of Agriculture Seed Lab in August 2022. The first contaminant seed I learned to identify was field pennycress, which has become my favorite because it symbolizes the beginning of my career in seed analysis. I had the privilege of working closely with several experienced seed analysts before they retired, and their guidance was invaluable as I prepared for the purity and germination exams. My coworkers organized practice tests and quizzes that helped me tackle potential questions and improve my seed identification skills. With the unwavering support of my family, friends, and amazing coworkers, I passed both exams—a feat my supervisor told me was unprecedented in the lab for 35 years. I take great pride in this achievement.

Honorary Memberships

David Johnston, AOSA Honorary Member

In 1987, David Johnston became a Certified Seed Analyst (CSA) in purity and germination. He was appointed as Lead Seed Analyst and Seed Lab Operational Manager at the Michigan Department of Agriculture.
In 2008, David accepted an appointment as Manager of SGS North America Seed Services. During his tenure, he continued to participate in numerous AOSA/SCST validation studies related to seed purity, germination, identification, and TZ testing.
In 2010, David moved to the Monsanto Vegetable Seed Quality Control Lab. During his time with Monsanto, David served as SCST co-chair of the Germination and Dormancy Subcommittee.
From 2016 to 2023, David served as the Seed Programs Coordinator/Seed Lab Manager and Seed Sampler Trainer for the Louisiana Department of Agriculture and Forestry where he oversaw the testing of seed samples for the purposes of seed law compliance, seed certification, and conducted and participated in multiple AOSA/SCST referee tests aimed at improving the rules.

David Johnston is one of the most prolific contributors of AOSA Rules change proposals, authoring or co-authoring proposals to ensure and promote uniformity in seed testing.
David has served as AOSA Vice President and President.

David's passion for seed testing and his commitment to AOSA objectives have made a lasting and significant contribution to our Association. For this David Johnston was nominated for Honorary Membership.

Harold Armstrong, SCST Honorary Member

Harold Armstrong achieved RST membership status in 2002 while working at Ag Reliant Genetics. He added the CGT in herbicide bio-assay accreditation in 2008. Harold moved to Monsanto in 2007, where he worked for 9 years. At Monsanto he worked as a technical expert in the physiology lab, and the developer of new test methods. After leaving Monsanto, Harold spent a short time at Advanta Seeds in Hereford, Texas. His final stop was Brookings, SD where he finally retired from SGS in 2021.

During his time as a member of the society Harold served on many committees and was the author of many Rule proposals and referee studies, serving as the SCST chair of the Referee Committee in the years before his retirement. Harold was a staple in the organization as a photographer ensuring our meeting and members were immortalized in photos. Harold's love of seeds extended outside of the lab as he is a Master Naturalist in several states. He was instrumental in the establishment of the Master naturalist program in South Dakota.

2024 Annual Meeting

Marija Topic & Beth Stewart

The AOSA/SCST Annual Meeting took place in Rapid City, South Dakota from June 1 – June 6. The conference was a resounding success, filled with a variety of engaging activities and opportunities for attendees. The event started with several workshops including Seedling Evaluation, Referee Testing and Application of Tolerances, Genetic Technology/Cultivar Purity, Lab Standards & Documentation providing valuable insights and hands-on experiences.

Newcomers were warmly welcomed with special orientation sessions designed to help them integrate and make the most of the conference.

Throughout the event, numerous research projects were presented, showcasing the latest advancements and innovative ideas in the field. These presentations sparked lively discussions and provided a platform for knowledge exchange among participants.

One of the highlights of the conference was the

Dr. Ruihong Guo (top) and Ernest Allen (Left) from USDA-AMS spoke at the Opening Session brunch. Highlights include an upcoming updated version of USDA Handbook 30, and increased harmonization between the ISTA and AOSA Rules as Ernest steps into his role as ISTA president at the ISTA annual conference this summer.

Members had the chance to visit trade show exhibitors and enjoy delicious hors d'oeuvres in the Dakota Ballroom. Many thanks to this year's sponsors and exhibitors!

large trade show, where exhibitors displayed their latest products and services. This provided attendees with a chance to explore new technologies and network with industry leaders.

The banquet, held in the Black Hills Ballroom, was a memorable occasion. One of the evening's highlights was the presentation of a special service award to Harold Armstrong, recognizing his outstanding contributions and dedication, adding a touch of celebration to the evening.

Overall, the conference was a fantastic opportunity for learning, networking, and celebrating achievements within both Associations.

After many years of active involvement with AOSA and SCST Harold Armstrong was awarded with an honorary membership to SCST. Harold was able to attend the banquet and receive his award and congratulations from the membership in person.

AOSA/SCST Field Trip to Mount Rushmore

Marija Topic & Beth Stewart, photos Quinn Gillespie

On Tuesday, June 4th, members of AOSA/SCST embarked on an exciting journey to Mount Rushmore. Despite a small delay due to a bus breakdown, the adventure began with a stop in Hill City, where the group boarded the historic 1880 Train. This steam train, which runs between Hill City and Keystone, provided a nostalgic experience as conductors shared fascinating facts about the area.

The Black Hills Central Railroad was added to the National register of Historical places in 1893.

After arriving in Keystone, members had the opportunity to explore the charming small shops in the town. The group then reboarded the buses and continued their journey to the iconic Mount Rushmore.

At Mount Rushmore, members scattered to walk the trails and take in the breathtaking sights of the monument. The free time allowed everyone to fully appreciate the grandeur and history of this national treasure.

Overall, the trip was a delightful field trip filled with exploration, learning, and camaraderie. It was a day well spent, creating lasting memories for all who attended.

Mount Rushmore in seen through the lane of state flags.

Committee Updates

As submitted by committee chairs

Communications & Publications

AOSA Chair—Kathryn McGinnis, SCST Chair—Quinn Gillespie

The Communications and Publications committee met August, 2024 to discuss the Newsletter, ongoing Indexing project, and the need for a place to publish ongoing research conducted by the organizations. To meet these goals the committee has established four working groups, each with three to four members, with the committee co-chairs as members of all working groups.

Technical Publications group—Members with strong research backgrounds, who will review technical publications, such as ongoing studies and summaries of projects presented at the Annual meeting.
Members: Ruojing Wang, Steve Jones, Eunsoo Choe, with Mark Anfinrud participating as time allows.

Editorial Group— Members who have a focus in editorial work and design to assist in proofreading articles for the Newsletter and Proceedings.
Members: Scottie Pouliot, Tammy Stark, Sarah Schulthies, Lauren Bogi, Maggie Risher

Indexing Group—Members who have volunteered for the time consuming task of reading through previous newsletters and assisting with the production of a comprehensive index of the publications of AOSA and SCST.
Members: Steve Jones, Kaitlin Korn, Scottie Pouliot, Tammy Stark

Outreach Group—Members with strong relationships across organizations to help AOSA and SCST improve our connections with the wider seed industry as a whole.
Members: Tammy Stark—ASTA Communications Committee, Steve Jones– past ISTA President, Todd Erickson—USDA

Cultivar Purity Committee

Chair—Diandra Viner

A 2023 version of the Cultivar Purity Handbook was released, and a correction/addition in May of 2024 regarding ryegrass genetic testing was incorporated. A potential committee merger with the Genetic Technology Committee needs further discussion on how to merge, meet and conduct business in the most effective way. And a webinar on "Ploidy Testing in Ryegrass" is a tentative topic to be offered when the time allows, so stay tuned!

Respectfully Submitted,
Diandra Viner, Cultivar Purity Sub-Committee chair

Referee Committee

AOSA Chair—Lan Chi Trinh, SCST Chair—Quinn Gillespie

The Referee Committee met in July, 2024 to review the notes from the Annual Meeting and topics generated at the Buzz Session. The committee discussed the proposed change within the committee to move from regional to categorical organization. AOSA members of the committee have drafted a proposal to reflect the change to categorical organization and submitted it to the AOSA Bylaws committee to be voted on at the next Annual meeting.

Several other topics were discussed, including possible methods to detect mechanical damage in onion seed, ammonia testing in fine fescues, updating purity weights for coriander mericarps. There are several projects already underway, including a study in basil seedling germination methods conducted by Nicolette Hard, comparison of Sorghum-Sudangrass germination days across seed testing rules, fava bean germination substrate evaluation, germination testing of FarMore treated pumpkin seed vs. non-treated, and a pea and soybean virtual seedling evaluation. There is also an ongoing project with the Purity committee to conduct mechanical seed counts on many different species to establish tolerances.

Statistics Committee chair, Karen Richard also requested that analysts sending data for review to the statistics committee allow a minimum of two weeks, preferably three or four, for complete data analysis. She is also planning to create a webinar on research papers and method validation data analysis which would allow members conducting studies to bring their own data and analyze it in real time.

Tetrazolium Committee

AOSA Chair—Beth Tatum, SCST Chair—Michael Aberle

At the annual meeting in South Dakota, the TZ chairs asked for volunteers to join the committee and we had a great response! Currently there are 16 members. We have had 2 Teams meetings since the annual meeting.

At the TZ committee meetings we have discussed plans to host a workshop before the 2025 annual meeting. The committee has decided what species and presentations will be included in the workshop. Also in the committee meetings, we share TZ images and discuss tips on methods for difficult species.

New Crop Alert: CoverCress®

Chris Aulbach, Brent Craig

Bringing a New Crop to Market Has Unexpected Challenges

For more than a decade, CoverCress Inc (CCI) and several other partners at Midwest Universities have been at the forefront of an ambitious endeavor: bringing a new crop, domesticated pennycress, to market. The introduction of a novel crop is a rare event in the United States and is accompanied by complex challenges that go beyond simply generating market demand. As innovation in agriculture continues at breakneck speed, new challenges and paradigm shifts need to be anticipated and solved.

CoverCress® pod set, Photo credit : CCI, 2024.

While this new crop has been recognized broadly at United States Agencies, including United States Department of Agriculture, Department of Energy and the Environmental Protection Agency, several hurdles remain before the crop can reach its true potential. Importantly, crop innovation will only speed up from here, highlighting the need for continued agile solutions.

Domesticated pennycress, marketed under the brand name CoverCress®, is a winter annual oilseed crop that produces an oil feedstock used for renewable fuels and meal that will be used as an animal feed. As a winter annual crop, it provides the ecosystem benefits of a functional cover crop and produces an oil feedstock with a low carbon intensity score. CCI has worked extensively with support from the USDA and University Collaborators to develop this new crop into a viable agricultural product for large-scale planting across the Corn Belt . Using advanced breeding tools and intensive selection efforts, the company developed a domesticated version of the plant that has much reduced seed dormancy, improved seed germination and other beneficial compositional and agronomic characteristics. Pennycress is in the same botanical family as Canola, and the breeding and development path for its domestication mimics the successful developmental path of Canola from Rapeseed many decades ago.

However, as domesticated pennycress is poised to expand its presence in American agriculture, there are some challenges to be overcome. First, the rise of this new crop prompts broader questions within the agricultural community: How should new crops be brought to market, and what is the best practice for establishing standardized rules and procedures to evaluate them? This issue is particularly pressing given the rapid pace of agricultural innovation and the growing demand for sustainable crop alternatives.

Additionally, in some states domesticated pennycress has not yet been recognized as a new crop , complicating the commercial opportunities available for the crop. This challenge stems from the weedy characteristics of the wild field pennycress which has seed known to have long dormancy period. Field pennycress is listed on some states restricted weed seed list, which may give some growers pause when considering this crop. Efforts are currently underway by CCI to collaborate with state seed departments , aiming to share information with stakeholders on the reduced weediness characteristics of the new crop and modify regulations where needed to align domesticated pennycress's status more closely with its crop relatives rather than its weedy origins.

As CCI continues to work toward overcoming these barriers, their progress underscores the multifaceted difficulties involved in bringing a new crop to market. It requires not only scientific innovation but also navigation at the state level and broad industry support to truly establish CoverCress® or domesticated pennycress as a sustainable agriculture crop.

1. https://www.federalregister.gov/documents/2024/06/27/2024-14126/procedures-for-quantification-reporting-and-verification-of-greenhouse-gas-emissions-associated-with; https://www.energy.gov/sites/default/files/2024-03/beto-2023-billion-ton-report_2.pdf;
2. Chemistry Science Advisory Council (ChemSAC) Minutes Database, January 24, 2024; To Allow Residue Data (tolerances) from Rapeseed subgroup 20A (canola) to be used to Establish a Pesticide Tolerance and Labeled Use Pattern for use on Pennycress in the United States.

For more information about testing protocols for this new crop kind, see Golden cress—For Analysts on page: 58

Devitalization of Lab Grown Plant Material by Freezing

Maranda Gillen, Brenda Johnson

Eurofins BioDiagnostics, LLC coordinated a multi-year project funded by the Seed Science Foundation (https://seedsciencefoundation.org/) (with support and participation from several transgenic trait providers and seed testing laboratories to establish freezing as an option for devitalizing lab-grown plant material.
The purpose of freezing laboratory grown seedlings before disposal is to implement a simple, efficient, and energy-conserving alternative to disposal of seedlings in compliance with regulations for stewarded and regulated material. See full report for details.

There is current collaboration with USDA-APHIS to answer technical and application questions regarding use of this method. Thank you to the Seed Science Foundation for fully funding this trial and to the following participants, in alphabetical order:

2020 Seed Labs Inc.
BASF Corporation
Bayer Seed Technology Center
Eurofins BioDiagnostics, LLC
Illinois Crop Improvement Association, Inc.
Indiana Crop Improvement
Iowa State University Seed Lab
Kent AgriLabs Ltd.
MDA Laboratory Services Division
SGS North America
SoDak Labs, Inc.
Syngenta Seeds Inc.

Freezing as Devitalization Tool:

A High Throughput Method for Germinated Seedlings Processed by Seed Testing Laboratories Following Regulated Seed Procedures
Article adapted from complete report submitted to Seed Science Foundation, 12/4/2024

1. Objective

The concept of freezing seedlings before disposal is a simple, efficient, and energy-conserving approach for devitalizing seed. The objective of the study funded by the SSF and supported by SCST and AEIC members, is to offer seed testing labs an alternative method to dispose seedlings while complying to stewardship or regulated requirements.

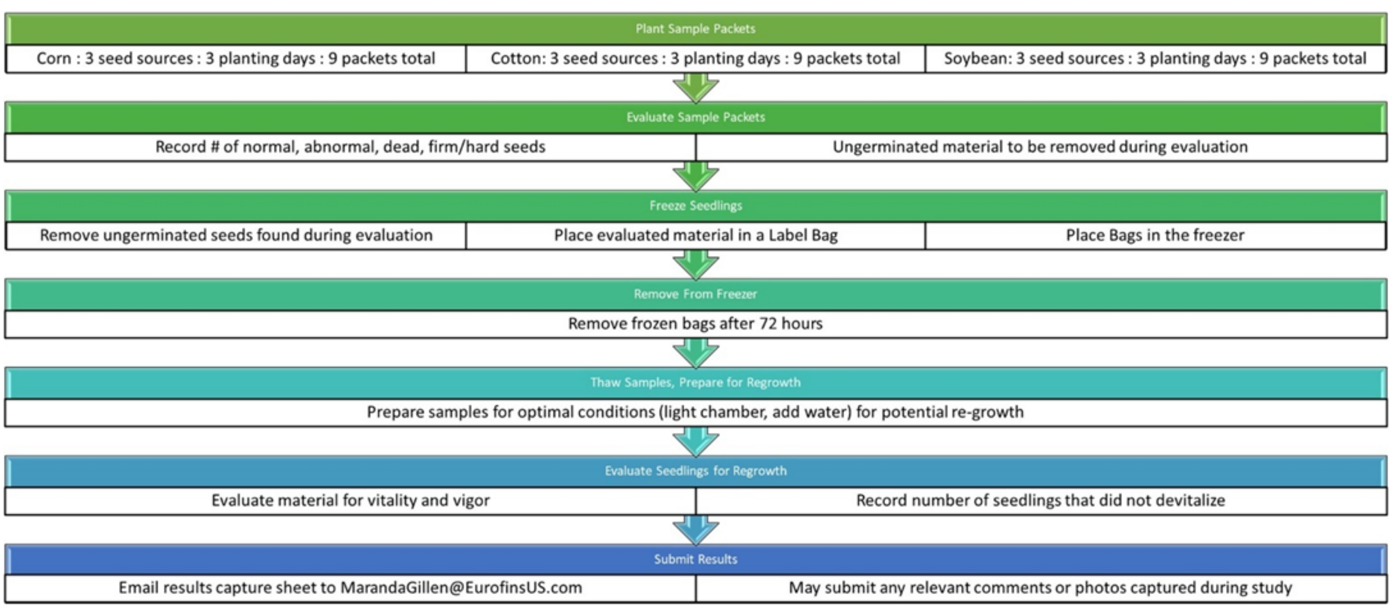
2. Overview

11 participating labs were called upon to conduct the freezing technique on germinated seedlings for crops corn, soybean, and cotton. Guidance was followed per the SSF and EBDI agreement, as well as the protocol presented during AEIC Fall 2021, and the SCST newsletter article of spring 2022.

3. Materials and Methods

From the efforts of the Genetic Technology Committee subgroup, EBDI collected seed material for the study, solidified the participant list, and reviewed the study objectives and outlines. Material was then distributed in participant shipments containing seed packets, results forms and instructions, and a few trash bags. Results were submitted back to EBDI in excel format.

3.2 Flow Chart of the Experiment



3.2 Participant Material List

The majority of the participating labs submitted results for all 3 crops, a few labs requested to receive only a subset of the full crop list.

Deviation: The 10th set of cotton packets were inadvertently sent to a lab that requested only corn and soybean, and the 10th set of cotton packets does not have data for the study.

Some of the labs indicating needing more bags than were sent in the shipment, and used additional bags from a different vendor, of comparable size.

DESCRIPTION	Qty	Unit
Trash bags for freezing	3	bag
Labels for freezer bags	3	label
Seed Packets- Corn	9	envelope
Seed Packets- Cotton	9	envelope
Seed Packets- Soybean	9	envelope
TOTAL:	27	

Packing list of study materials sent to participants

Image of the packing list of study materials. (See inset)

3.3 Participant Instructions

The instructions sent to participants in the study material packet reads as follows.

Only non-regulated material has been submitted in the participant seed devitalization packet.
For the study purposes, please adhere to all regulated material handling procedures.
Participation implies use of the provided materials for the purpose of this study only.
Recipient agrees that all provided material including seed will not, directly or indirectly, be reverse-engineered, exported, transferred, and/or sold, or offered for sale anywhere in the world, and will not be used for any purpose other than execution of Seed Devitalization Study funded by Seed Science Foundation.
Submit results by May 1st, 2023.
Contact Maranda Gillen, Eurofins BioDiagnostics, Inc for questions. marandagillen@eurofinsus.com; 651-318-7820

Packet Inventory

# Packets	Crop	Seed Source Types	Planting Intervals	Planting Interval Scheme
9	Corn	Source 1, Source 2, Source 3	Day 1, Day 2, Day 3	Please plant seed sources 1-3 on each planting day. Will result in 3 packets planted per day, over 3 days total.
9	Cotton	Source 1, Source 2, Source 3	Day 1, Day 2, Day 3	Please plant seed sources 1-3 on each planting day. Will result in 3 packets planted per day, over 3 days total.
9	Soybean	Source 1, Source 2, Source 3	Day 1, Day 2, Day 3	Please plant seed sources 1-3 on each planting day. Will result in 3 packets planted per day, over 3 days total.
27 Total				

Planting
Seed overage has been supplied in each packet. Plant 400 seeds following AOSA approved, standard warm germination method.
For each crop, plant seed sources 1-3 on each planting day. 3 packets per crop are to be planted on each day.
Crops can be planted on the same or different planting days. Up to 9 packets (across 3 crops) total can be planted on each day.
Record the planting dates and media types (rolled towels, kimpack, etc) on the capture sheet.
Evaluation
For ease of evaluation that will occur during the regrowth evaluation step, it is recommended to not greatly displace the evaluated seedlings.
Record the evaluation date, and the evaluator on the capture sheet. Please indicate if RST guidance was available.
Remove the dead seeds found during evaluation. Dispose/devitalize dead count.
Freezing
Record the condition of the normal and abnormal seedlings to be frozen (retained in planting media or pulled off) on the capture sheet.
Label the 5 gallon trash bag. Place evaluated material into the bag, seal, weigh, and freeze.
Samples are to be placed into an approved 5 gallon trash bag (1 ft 11-15/32 in x 2 ft 1-3/8 in or 59.6 cm x 64.5 cm). Trash bag fill-weight limit is 3200g or ~35 rolled towels.
Record the bag ID and weight, freezer temperature, and date frozen on the capture sheet.
Pull from Freezer
After 72 hours, remove the bag from the freezer location.
Prepare the samples to facilitate growth. Example: Put towels back into buckets, add water, store under light conditions.
Record the date removed from the freezer, regrowth location and temperature.
Regrowth Evaluation
Recommended evaluation is 2 days after pulling out of the freezer. Evaluate the seedlings for vigor and vitality. If results are not definitive, extend the regrowth period.
Record the date of the regrowth evaluation and the evaluator on the capture sheet. Please indicate if RST guidance was available.
Record the # of seedlings with regrowth on the capture sheet.
Samples may be disposed after regrowth evaluation is conducted.
Submit Capture Sheet Results
Please email the completed capture sheet to marandagillen@eurofinsus.com
Add comments and pictures as needed to the file.
Results are requested to be submitted by May 1st, 2023, to be compensated for study participation.

3.4 Participant Capture Sheet for Recording Results

Below is an image of the excel file participants recorded results from the study.

Participating Lab	Sample #	Crop	Sample ID	Planting Interval	Planting Date	Planting Media	Evaluation Date	Evaluator Initials & Credentials	#Seeds Evaluated	#Normal Seedlings	#Abnormal Seedlings	#Dead (Removed)	Condition of Germination Material to Freeze (retained on germination towels/media)	Freezer Bag ID	Freezer Bag Weight	Freezer Temp	Freeze Date	Date Removed from Freezer	Regrowth Location	Regrowth Temperature	Date Evaluated for Regrowth	Regrowth Evaluator Initials & Credentials	# Seedlings with Regrowth	Comments
EBDI Example	123999999	Corn	Example 1	Example 1	6/4/2022	paper towel	6/11/2022	HP RST	400	389	10	1	Seedlings retained on rolled towels	06/11/2022, Ex1	1500g	-20C	6/11/2022	6/14/2022	25C chamber	25C	6/16/2022	HP RST	0	none
1	1	Corn	1	1					400															
1	2	Corn	2	1					400															
1	3	Corn	3	1					400															
1	4	Cotton	1	1					400															
1	5	Cotton	2	1					400															
1	6	Cotton	3	1					400															
1	7	Soybean	1	1					400															
1	8	Soybean	2	1					400															
1	9	Soybean	3	1					400															
1	10	Corn	1	2					400															
1	11	Corn	2	2					400															
1	12	Corn	3	2					400															
1	13	Cotton	1	2					400															
1	14	Cotton	2	2					400															
1	15	Cotton	3	2					400															
1	16	Soybean	1	2					400															
1	17	Soybean	2	2					400															
1	18	Soybean	3	2					400															
1	19	Corn	1	3					400															
1	20	Corn	2	3					400															
1	21	Corn	3	3					400															
1	22	Cotton	1	3					400															
1	23	Cotton	2	3					400															
1	24	Cotton	3	3					400															
1	25	Soybean	1	3					400															
1	26	Soybean	2	3					400															
1	27	Soybean	3	3					400															

4. Summary of results

4.1 Corn Results

Across all participating labs and 36,000 total seeds evaluated, there were zero corn seedlings with regrowth indicated. The upper bound of true impurity calculated is below 0.01%. Further calculations indicate the maximum likely level of possible survival with upper bound at 99% CI is 0.0083211. This is based on the statistics (SeedCalc) and zero survival, on the number of pools (10 labs) and the number of seeds per pool/lab (3600). See table 1 in 4.4 for results by lab breakdown. See image 1 in 4.4 for Seedcalc analysis.

4.2 Soybean Results

Across all participating labs and 36,000 total seeds evaluated, there were zero soybean seedlings with regrowth indicated. The upper bound of true impurity calculated below 0.01%. Further calculations indicate the maximum likely level of possible survival with upper bound at 99% CI is 0.0083211. This is based on the statistics (SeedCalc) and zero survival, on the number of pools (10 labs) and the number of seeds per pool/lab (3600). See table 1 for results by lab breakdown. See image 1 for Seedcalc analysis.

4.3 Cotton Results

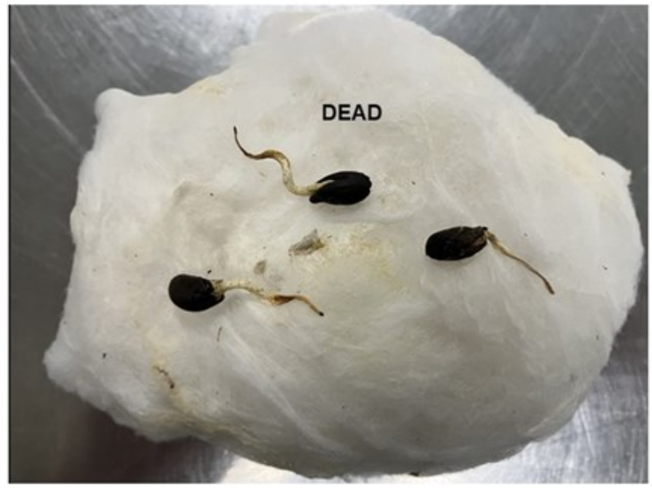
Across all participating labs and 32,400 total seeds evaluated, there were 34 cotton seedlings with regrowth indicated. The upper bound of true impurity calculated below 0.14%. See table 1 for results by lab breakdown. See image 2 for Seedcalc analysis. See table 2 for lab comments regarding cotton evaluation.

Several labs indicated firm and hard seed was present during analysis, and there appeared to be discrepancies between how labs handled the removal of ungerminated material prior to freezing. 2 labs that had removed firm/ungerm seed prior to freezing, provided images of suspicious seedlings. 1 lab continued to place the seedlings under regrowth conditions for an additional 24 hours, and ultimately called the seedlings dead (lab 9), the other lab (5) noted the seedling condition and marked as regrowth indicated.

Lab 9- before and after images of dead seedlings that received an additional 24 hours of regrowth conditions

Suspicious

Regrowth – After 24h



Lab 5- image of seedlings that scored as regrowth

4.5 Analysis tables and Images

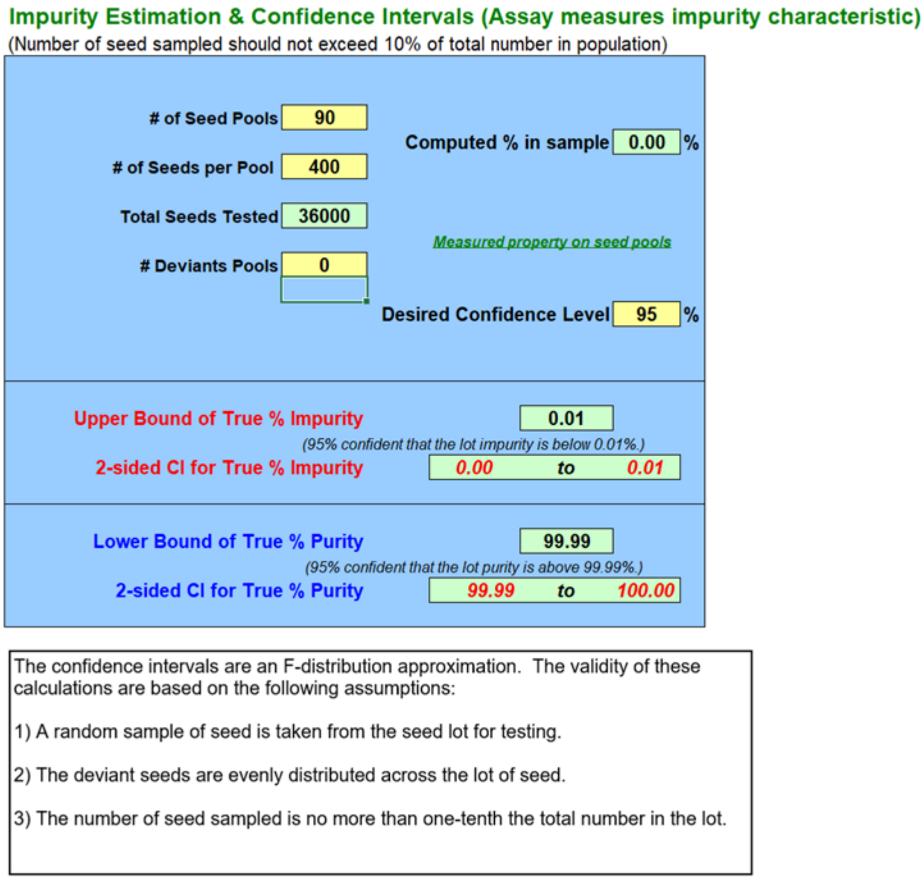
Table 1: Number of seedlings with regrowth per lab.

Crop-Participating lab	Sum of # Seeds Evaluated	Sum of # Seedlings with Regrowth
Corn	**36000**	**0**
1	3600	0
2	3600	0
3	3600	0
4	3600	0
5	3600	0
6	3600	0
7	3600	0
8	3600	0
9	3600	0
10	3600	0
Cotton	**32400**	**34**
1	3600	0
2	3600	0
3	3600	25
4	3600	3
5	3600	5
6	3600	0
7	3600	1
8	3600	0
9	3600	0
10		
Soybean	**36000**	**0**
1	3600	0
2	3600	0
3	3600	0
4	3600	0
5	3600	0
6	3600	0
7	3600	0
8	3600	0
9	3600	0
10	3600	0
Grand Total	**104400**	**34**

Table 2: Comments about the cotton samples per lab.

Partipating Lab - Cotton comments
Cotton
1
hard, firm ungerm recorded in dead pulled off colum
3
15 hard seeds
2 hard seeds
2 hard seeds (Post freeze: one regrowing, 1 hard)
4 hard seeds
7 hard seeds
4
*Sample is a mixture of sources 1,2,3. For the cotton that showed growth, the roots grew longer, and the hypocotyl began to elongate more than what was seen previously. MG added via email 4/10/23 from D A-O
6
0 HARDS; significant decay after regrowth period
100 HARDS; significant decay after regrowth period
23 HARDS; significant decay after regrowth period
27 HARDS; significant decay after regrowth period
37 HARDS; significant decay after regrowth period
4 HARDS; significant decay after regrowth period
44 HARDS; significant decay after regrowth period
5 HARDS; significant decay after regrowth period
54 HARDS; significant decay after regrowth period
9
Suspicious - Put it back on Growth Chamber for 24h, but all seeds were dead after that

Image 1: SeedCalc analysis for corn and soybean results



Impurity Estimation & Confidence Intervals (Assay measures impurity characteristic)
(Number of seed sampled should not exceed 10% of total number in population)

# of Seed Pools	90
# of Seeds per Pool	400
Total Seeds Tested	36000
# Deviants Pools	0
Computed % in sample	0.00 %
Desired Confidence Level	95 %

Measured property on seed pools

Upper Bound of True % Impurity: 0.01
(95% confident that the lot impurity is below 0.01%.)
2-sided CI for True % Impurity: *0.00 to 0.01*

Lower Bound of True % Purity: 99.99
(95% confident that the lot purity is above 99.99%.)
2-sided CI for True % Purity: *99.99 to 100.00*

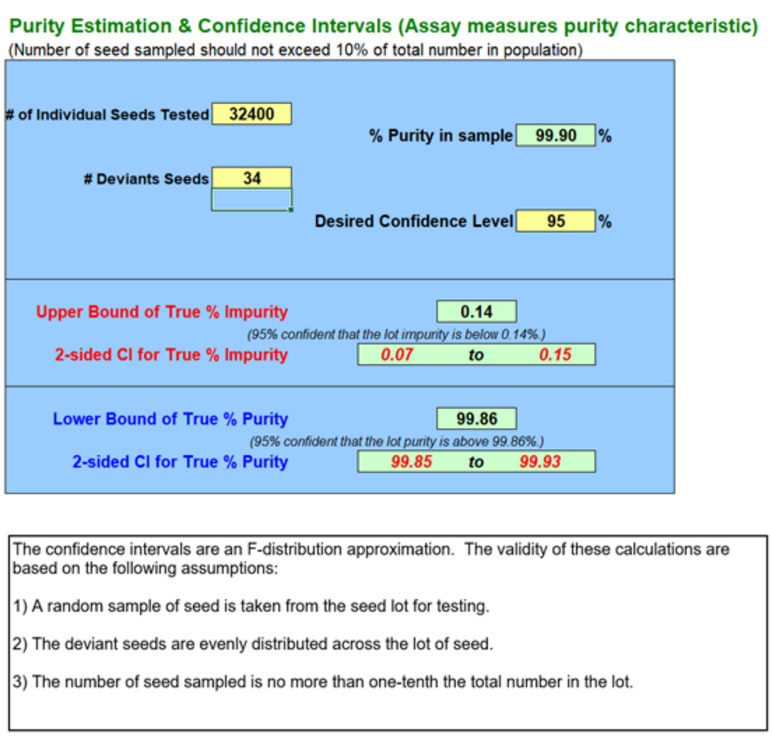
The confidence intervals are an F-distribution approximation. The validity of these calculations are based on the following assumptions:

1) A random sample of seed is taken from the seed lot for testing.

2) The deviant seeds are evenly distributed across the lot of seed.

3) The number of seed sampled is no more than one-tenth the total number in the lot.

Image 2: SeedCalc analysis for cotton results



Purity Estimation & Confidence Intervals (Assay measures purity characteristic)
(Number of seed sampled should not exceed 10% of total number in population)

# of Individual Seeds Tested	32400
# Deviants Seeds	34
% Purity in sample	99.90 %
Desired Confidence Level	95 %

Upper Bound of True % Impurity: 0.14
(95% confident that the lot impurity is below 0.14%.)
2-sided CI for True % Impurity: *0.07 to 0.15*

Lower Bound of True % Purity: 99.86
(95% confident that the lot purity is above 99.86%.)
2-sided CI for True % Purity: *99.85 to 99.93*

The confidence intervals are an F-distribution approximation. The validity of these calculations are based on the following assumptions:

1) A random sample of seed is taken from the seed lot for testing.

2) The deviant seeds are evenly distributed across the lot of seed.

3) The number of seed sampled is no more than one-tenth the total number in the lot.

5. Discussion/Next Steps

The discussion of where to go next with the results from the study continues, efforts need to be made to bring the findings to trait providers who apply for USDA permits that list the allowed methods of devitalization.

There is also discussion needed if there is special consideration needed for handling germinated cotton material when firm and ungerminated material presents itself in a sample. It would be beneficial to evaluate the cotton results further with a new study that has germination and evaluation practices tailored to the crop, and to account for consistent procedure to evaluate regrowth, such as setting the regrowth period for 5 days instead of 3 for all cotton samples. It would also be of interest to see if the statistical regrowth % indicated in this study is within the expected outcome of other approved devitalization methods such as autoclaving.

Cotton After 72 Hours in -20C Chamber

Cotton After 48 Hours in 25C Light Chamber— All seedlings deemed devitalized.

Photos courtesy EBDI.

DNA vs. RNA

Genetic Technology Committee

A one-letter difference, but two unique biological molecules. Deoxyribonucleic acid (DNA) has a double helix structure, meaning it looks like a spiral staircase. This is due to alternating 2-deoxyribose sugar and phosphate that covalently bond to create the backbone, or if sticking with the staircase analogy, the railings. This formation adds stability and protection to the "steps". The steps in this staircase are built with nitrogenous bases: adenine, guanine, cytosine, and thymine. When a nitrogenous base attaches to the sugar-phosphate backbone, this is known as a nucleotide. These nucleotides form hydrogen bonds with adenine pairing with thymine (2 hydrogen bonds) and guanine with cytosine (3 hydrogen bonds), known as complementary base pairing. The order of nucleotides is the blueprint for the genetic information of an organism. Additionally, the amount of GC (guanine-cytosine) vs AT (adenine-thymine) pairings influences the DNA strand's stability and structural complexity, which can be beneficial to the organism but can make the life of the DNA technician more difficult when designing PCR protocols.

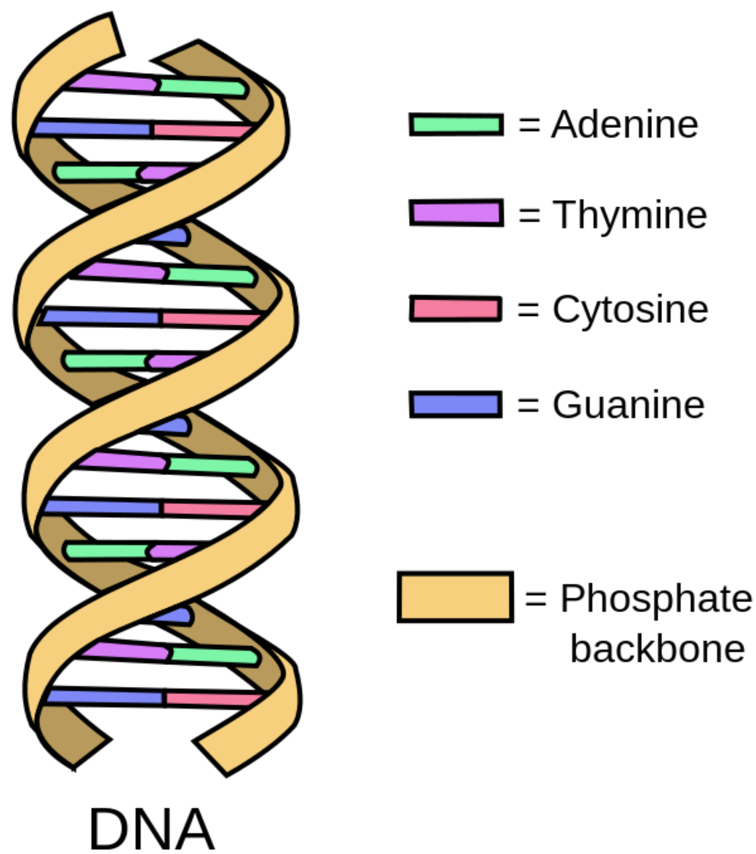


Fig. 1: Diagram of DNA double helix with base pairs and phosphate backbone color coded. (*Help is here!* (2013). Hartnell.edu. http://www.hartnell.edu/tutorials/biology/dnareplication.html)

Ribonucleic Acid (RNA) is a shorter single-stranded polymer with a ribose sugar and phosphate backbone. While also made up of nucleotides, it replaces thymine for uracil. While DNA protects and stores the organism's genetic material in the cell's nucleus, RNA's role is the transcription of the DNA code and then transferring the information(mRNA) to the ribosomes in the cytoplasm to translate (rRNA) and build amino acids (tRNA) which then go on to form proteins, which then go on to perform the essential metabiological functions of the organism. Basically, think of RNA as the ultimate personal assistant for a CEO. While these nucleic acids have different functions and structures, they work together to provide essential functions for basic forms of life.

Analysis of Soybean Development after Mechanical Damage at the Embryonic Axis

Eunsoo Choe, RST, PhD.

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Email: echoe@ilcrop.com

Abstract

Soybean mechanical damage is one of the essential factors affecting seed soybean quality. The fracture at the cotyledon or the embryonic axis of the seed is one type of mechanical damage in soybeans. Some soybean seeds with damage at the embryonic axis recover and develop normal seedlings. Studies have reported the damage and the effect of the damage. However, no study has been conducted on controlled mechanical damage at the embryonic axis, and no reports have been made on their recovery from injury. The objectives of this research were to: 1) elucidate soybean germination after controlled mechanical damage at the embryonic axis, 2) compare germination recovery on the damage at different parts of the axis, and 3) compare germination recovery on different genetic backgrounds. Three soybean (*Glycine max*) cultivars harvested in 2022 and 2023 were used in the study with the three damage types, at radicle tip, mid-radicle (hypocotyl), and whole radicle (up to epicotyl), in addition to un-damaged control. The number of dead, abnormal, and normal seedlings were collected on four replications of 25 seeds per treatment. After the evaluation, the dry weight of root and hypocotyl, percent dry weight of root and hypocotyl, number of secondary roots, length of the longest root and hypocotyl, and percent length of the longest root and hypocotyl were collected on five normal seedlings per replication per treatment. Most soybeans recovered from the damage and were evaluated as normal seedlings at the end of the germination period. No significant difference was observed in total germination among un-damaged, damage at the radicle tip, and mid-radicle. On average, damaged seedlings developed from 4 to 7 secondary roots across the treatments and cultivars. The weights and lengths of the roots and hypocotyl decreased as more damage occurred. However, there was no significant difference in the root dry weight of the seedlings, with damage at the radicle tip and un-damaged control. Moreover, all treatments for certain cultivars showed a comparable percentage of root and hypocotyl length and mass. Significant differences in root and hypocotyl development patterns in length, mass, and number of secondary roots were observed among cultivars. These research findings are the first to quantify and report the seedling recovery after mechanical damage and will help understand seed development after damage. Further research is being conducted at the University of Illinois to investigate the development of damaged seeds in the field.

Introduction

Successful germination is pivotal for ensuring robust seedling establishment and maximizing crop yield. However, mechanical damage during seed harvesting, processing, and planting can significantly compromise seedling performance. Mechanical damage to soybean (*Glycine max*) seeds is one of the critical factors influencing soybean seed quality and potentially impacts various tissues, including the embryonic axis. The embryonic axis, which includes the radicle, hypocotyl, and epicotyl plays a fundamental role in seedling development and germination. Studies discussed that damage to this critical structure could impair water uptake, disrupt nutrient transport, and hinder the overall growth process, reducing germination rates and weakening seedlings (Ning et al., 2014; Goli et al., 2016). The degree of soybean mechanical damage is affected by seed moisture, seed size, or seed coat integrity. As the term implies, mechanical handling creates damage, and various seed testing procedures such as seed coat damage are available to assess soybean mechanical damage (Gutormson et al., n.d.). Previous studies also discovered genetic differences in mechanical damage susceptibility indicating soybeans can be improved from mechanical damage (Carbonell & Vello, 2001).

Soybean mechanical damage impacts seed tests and can create variations in germination readings and interfere with uniformity in seed testing. Normal seedlings from mechanically damaged soybean seeds are often observed in seed laboratory germination conditions and that could be referred to as the seedling recovery from mechanical damage. The Association of Official Seed Analysts rules for testing seeds Volume 4 Seedling Evaluation explains normal seedlings from mechanical damage using drawings and description of normal hypocotyl length or sufficient secondary roots. However, the empirical description of how mechanically damaged seeds grow into normal seedlings is limited. Moreover, the Tetrazolium Chloride (TZ) testing Handbook lacks the evaluation of mechanically damaged soybeans which may create a gap between germination and TZ result. Previous studies have examined the effects of non-specific mechanical damage using tests such as drop tests, stationary threshers, and pendulum tests on seed viability and vigor (Goli et al., 2016; Ning et al., 2014; Carbonell & Vello, 2001; Mason et al., 1982). Notably, Mason et al (1982) showed that mechanical damage from drop tests on one soybean cultivar decreased field emergence. When standard germination, TZ testing, and cold test results were compared for field emergence, standard germination results were better at estimating field emergence than the other testing with a high variation on an increased level of mechanical damage (Mason et al., 1982). A detailed report on controlled damage at the embryonic axis and subsequent recovery will improve the understanding of seedling growth from damaged seeds and help reduce variation in interpreting the damaged seeds and seedlings.

The objectives of this research are (1) to elucidate the effects of controlled mechanical damage at the embryonic axis on soybean germination, (2) to compare germination recovery following damage to different parts of the embryonic axis, and (3) to assess germination recovery across different genetic backgrounds. By addressing these objectives, this study aims to provide the first report on the recovery of soybean germination after controlled mechanical damage at the embryonic axis and inform strategies for seed analysts and plant breeders to further an in-depth understanding of seedling growth and the selection of resilient soybean varieties.

Materials and Methods

Three soybean cultivars, LD11-2170, LD15-3818, and LD15-5789800, produced in 2022 and 2023 from the University of Illinois at Urbana-Champaign were used in the experiment. Three types of damage on the embryonic axis were performed by cutting the embryonic axis at about 1/3 away from the tip (radicle damage), 2/3 away from the tip (hypocotyl damage), and the entire embryonic axis (epicotyl damage) on dry soybean seeds. Germination testing was performed on four replications of twenty-five seeds of three damaged treatments and un-damaged at the Illinois Crop

Improvement Association. Each twenty-five seed set of replications was planted in a rolled towel in a vertical position at 25 °C for seven days. Seedlings were evaluated to be normal, abnormal, and dead seven days after planting. On five normal seedlings, the number of secondary roots, the longest root length (RL), hypocotyl length (HL), root dry weight (RW), and hypocotyl dry weight (HW) were measured. After the measurements, root length and weight proportions were calculated by root length or weight / total seedling length or weight (hypocotyl length or weight + root length or weight) * 100. Statistical analysis on all measurements was performed using JMP 17.2.0. Mean separations were performed using the Tukey HSD procedure.

Results and Discussion

Three cultivars used in this study were selected based on their high quality without other damages so that the effect of damage treatment can be accurately determined. Germination and accelerated aging test results on the cultivars from 2022 and 2023 showed relatively high viability with varying vigor depending on the year they were harvested (Table 1). Despite the cultivars from 2022 having significantly lower vigor than those from 2023, the analysis of variance showed that the effect of year was not significant for the measurements of lengths and weights of recovered seedlings (Table 2). It indicates that the seed vigor or the environmental effect did not significantly affect the seedling recovery from embryonic axis damage.

Table 1. Seed counts, mean germination, and accelerated aging results on the cultivars used for this experiment.

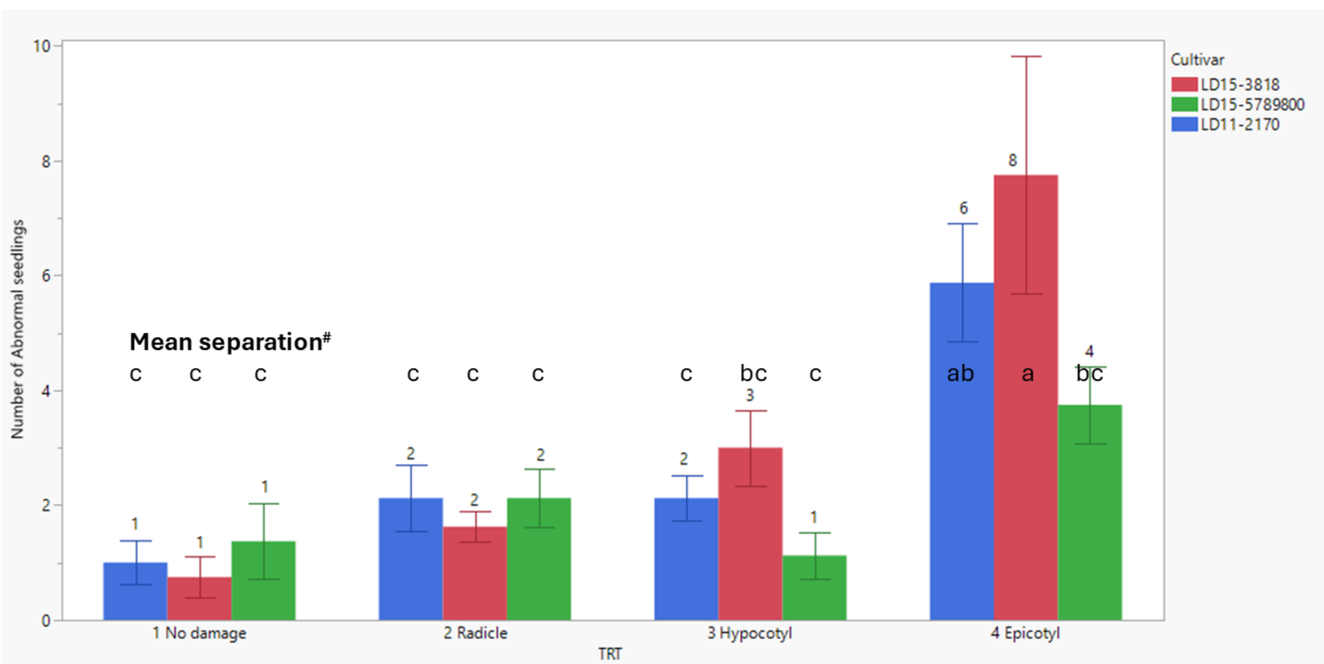
Years	Cultivars	Seed Count (Number of seeds/LB)	Germination (%)	Accelerated Aging results (%)
2022	LD15-5789800	2628	84	15
2022	LD11-2170	2675	91	29
2022	LD15-3818	2788	95	23
2023	LD15-5789800	2641	98	92
2023	LD11-2170	2858	99	88
2023	LD15-3818	2940	99	99

Table 2. Analysis of variance table for all measurements. * p-value significant at alpha = 0.05.

Sources	Dead	Abnormal	Number of secondary roots	Hypocotyl length	Root length	Percent hypocotyl length	Hypocotyl weight	Root weight	Percent hypocotyl weight
					Prob > F				
Cultivars	0.0051*	0.0789	<.0001*	<.0001*	0.0664	<.0001*	<.0001*	<.0001*	<.0001*
Year	0.0002*	<.0001*	0.0102*	0.7338	0.9940	0.3612	0.8778	0.6559	0.3965
Treatment (TRT)	0.4598	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*
Cultivars x Year	0.0171*	0.6252	0.6759	0.1079	0.2681	0.0733	0.1454	0.0209*	0.0034*
Cultivars x TRT	0.3269	0.0483*	0.0001*	0.6904	0.1282	<.0001*	0.0046*	0.1255	<.0001*
Year x TRT	0.8197	0.4772	0.4884	0.7643	0.0019*	0.3654	0.3548	0.3086	0.5454
Cultivars x Year x	0.7173	0.1936	0.3115	0.2952	0.0243*	0.4483	0.4695	0.176	0.3067

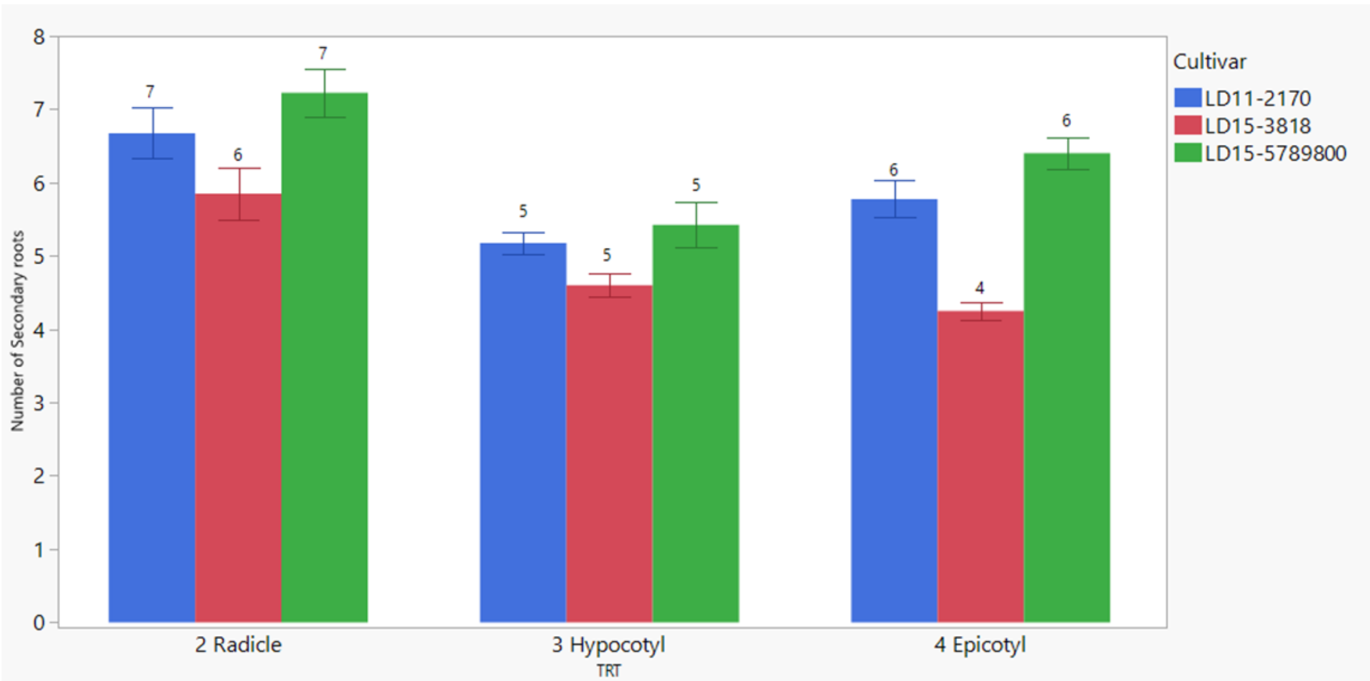
The effect of damage treatment at the embryonic axis was highly significant for all measurements except the number of dead indicating the damage treatment did not cause seed death yet affected how the seedlings grew (Table 2). The number of abnormal seedlings was only significantly increased by the damage at the epicotyl for LD11-2170 and LD15-3818 (Figure 1). Most of the abnormal traits were found to have missing essential structures, insufficient secondary roots, short hypocotyls, and/or negative geotropism. The number of abnormal seedlings for other damage treatments was not significantly different from the un-damage treatment indicating soybean seeds do recover from embryonic axis damage and produce normal seedlings during germination testing. Interestingly, even when the entire embryonic axis was removed (epicotyl damage), some soybean seeds produced normal seedlings suggesting soybean seeds can generate essential structures simply from the remaining shoot apex. Yet, the numbers were varied by cultivar. LD15-3818 was more variable and demonstrated a higher number of abnormal seedlings than other cultivars.

Figure 1. The mean number of abnormal seedlings for cultivars by each damage treatment. # Different letters indicate that the mean was significantly different from other mean at alpha= 0.05.



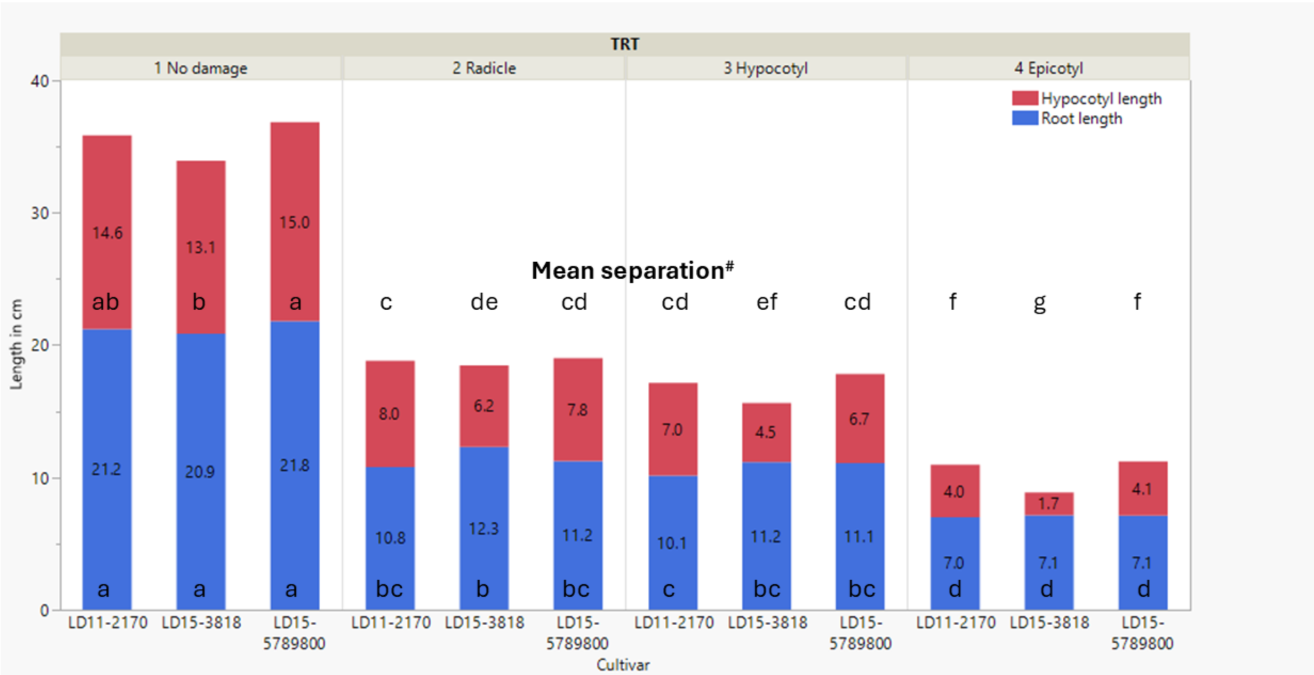
The normal seedlings from damage treatments developed from four to seven secondary roots on average (Figure 2). The cultivars, damage treatments, and the interaction between cultivars and treatments were highly significant affecting the number of secondary roots (Table 2). The seedlings with the damage at the radicle produced higher numbers of secondary roots in general than other types of damage within the same cultivar. Still, seedlings with damage at the radicle and epicotyl on LD15-589800 produced similarly high numbers of secondary roots while seedlings with radicle damage on LD15-3818 produced a significantly smaller number of secondary roots than those with epicotyl damage on LD15-589800.

Figure 2. The mean number of secondary roots for cultivars by each damage treatment.



Hypocotyl length and root length decreased significantly as more parts of the embryonic axis were removed from the seeds (Figure 3). Hypocotyl length on un-damaged seedlings was 14.3 cm on average compared to 3.3 cm on epicotyl-damaged seedlings whereas root length on un-damaged seedlings was 21.3 cm on average compared to 7.1 cm on epicotyl-damaged seedlings. The damaged seedlings at radicle and hypocotyl showed similar hypocotyl and root length so these treatments may have resulted in a similar biological response and can be reduced to one treatment in future experiments. The effect of cultivars was significant on hypocotyl length, while root length was not significantly affected by cultivars (Table 2). LD15-3818 produced significantly shorter hypocotyls than LD11-2170 and LD15-5789800 for all corresponding damage treatments indicating cultivars responded differently to embryonic damage.

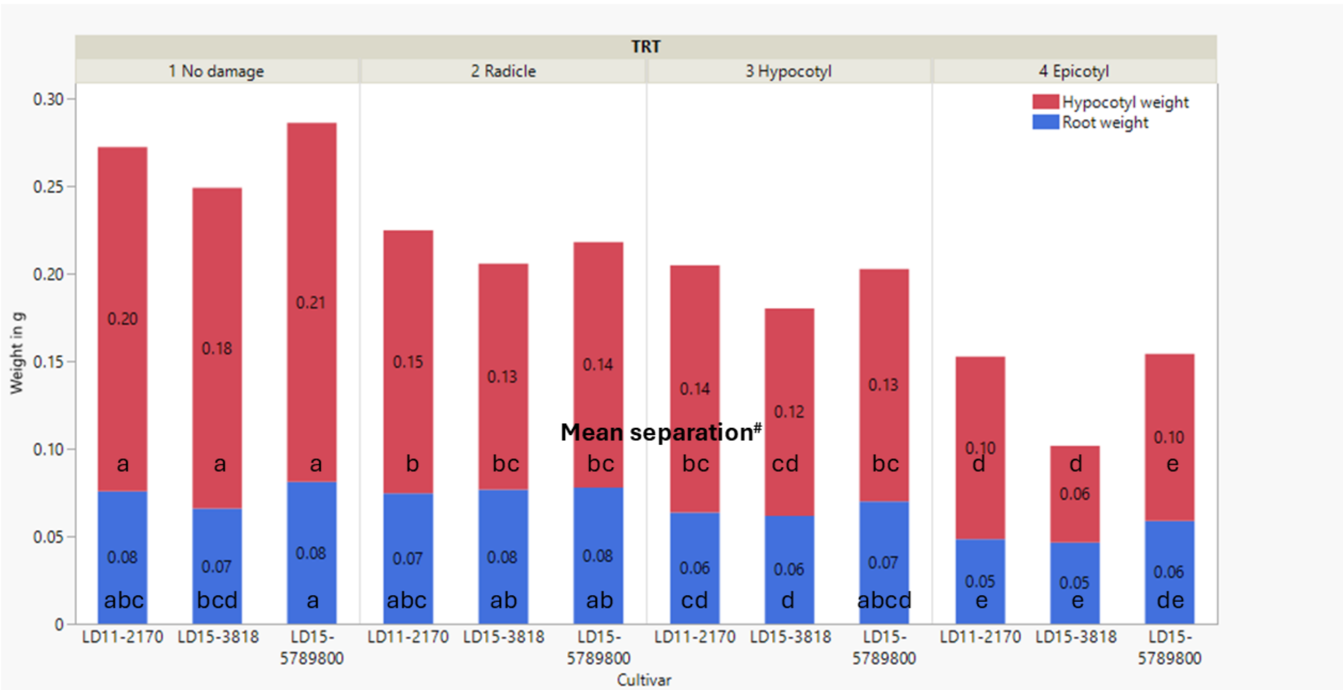
Figure 3. The mean hypocotyl and root length for cultivars by each damage treatment. # Different letters indicate



that the mean was significantly different from other mean at alpha= 0.05.

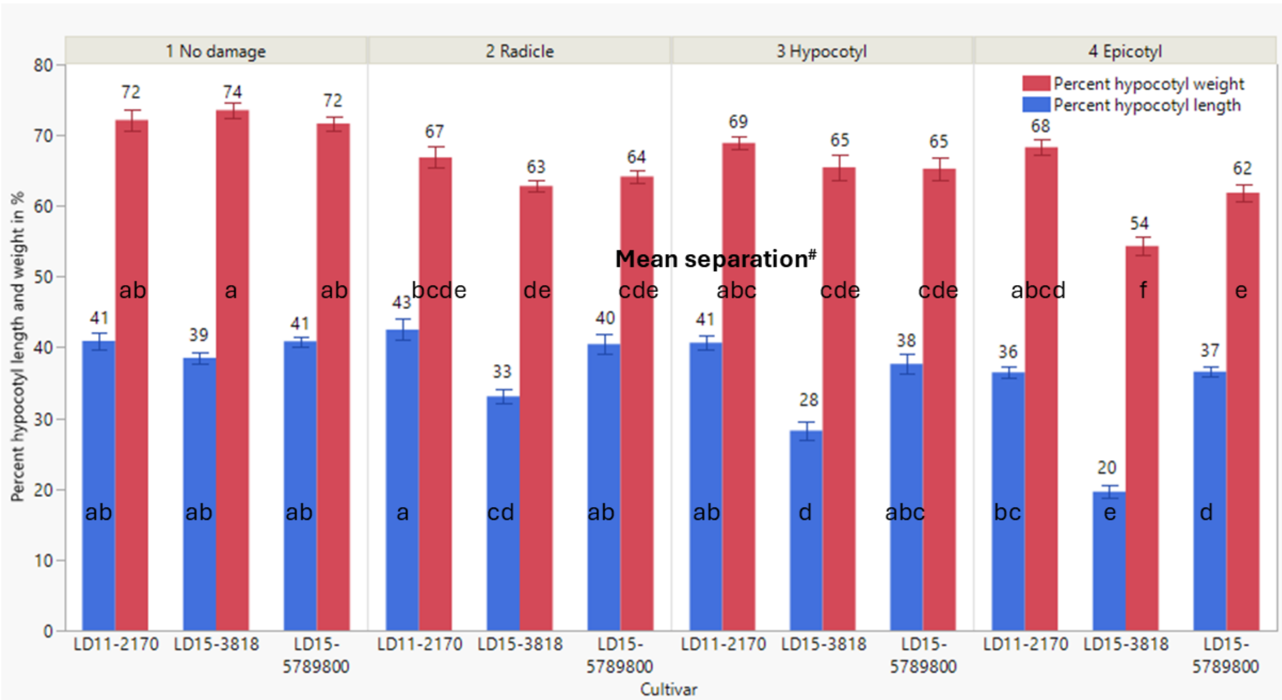
Since the root length stayed consistent within the cultivars and differed only by damage treatments, the percent hypocotyl length showed a strong decrease for each damage treatment on LD15-3818 (Figure 4). Un-damaged seedlings produced about 40% hypocotyl length and damaged seedlings of LD11-2170 and LD15-5789800 had similar hypocotyl length percentages (36% and above). On the other hand, radicle, hypocotyl, and epicotyl-damaged LD15-3818 showed significantly smaller hypocotyl length percentages compared to un-damaged seedlings with 33%, 28%, and 20%, hypocotyl length respectively.

Figure 4. The mean percent hypocotyl length and weight for cultivars by each damage treatment. # Different letters indicate that the mean was significantly different from other mean at alpha= 0.05.



While the length of damaged seedlings was significantly affected by damage treatment, root dry weight on radicle-damaged seedlings showed a similar root weight to the un-damaged seedlings (Figure 5). In other words, the normal root growth from un-damaged seeds can be comparable to the secondary root production from radicle-damaged seedlings. For LD15-3818, radicle-damaged seedlings produced significantly higher root dry mass than un-damaged seedlings. Hypocotyl dry weight of all damaged seedlings was significantly lower than un-damaged seedlings similar to the finding on hypocotyl length.

Figure 5. The mean hypocotyl and root dry weight for cultivars by each damage treatment. # Different letters indicate that the mean was significantly different from other mean at alpha= 0.05.



Un-damaged seedlings produced about 72% of hypocotyl dry mass. For most cases, the hypocotyl dry weight percentage decreased as more embryonic axis was removed from the seeds. For LD11-2170, however, hypocotyl dry weight percentages for all damage treatments were comparable to un-damaged hypocotyl dry weight percentages (72%) ranging from 67% to 69% (Figure 4) indicating that damaged LD11-2170 seedlings produced proportionally similar hypocotyl to root percentage compared to un-damaged seedlings.

No research explains how damaged soybean seeds at the embryonic axis grow into normal seedlings. Our observation found normal seedlings after damage at the embryonic axis developed essential structures such as hypocotyls and sufficient secondary roots. The differentiation of hypocotyls and secondary roots occurred at the damaged sites. The soybean embryonic axis has the root and shoot meristematic tissues with undifferentiated cells capable of cell division that develop into a different organ. One possible explanation of the recovery after soybean embryonic axis damage is that the remaining embryonic axis tissue after the damage may consist of meristematic cells that are sufficient to produce the hypocotyl and secondary roots. The other possible explanation of the recovery can be from the plant regeneration mechanism from wound response. *De novo* root organogenesis is the type of plant regeneration process that usually explains adventitious root formation in detached leaves without exogenous hormone supplementation (Lee & Seo, 2022). When the embryonic axis is damaged and imbibes water, it may trigger a regeneration mechanism as a defense response that is different from the normal germination process. Further investigation of the germination of damaged seeds at a cellular and molecular level may open new scientific insight.

Summary and Plans

This experiment demonstrated and quantified seedling recovery from embryonic axis damage from standard germination and discovered evidence of genetic variation in seedling recovery. The findings could lead to advancements in seed technology and open new breeding opportunities. Most normal seedlings from damaged seeds produced shorter and smaller hypocotyl and secondary roots than un-damaged seedlings, but in some cases, root dry weights, percent hypocotyl length, and weight of damaged seedlings were comparable to un-damaged seedlings. Seedlings showed recovery from embryonic axis damage in the laboratory yet, it is unknown if these same seedlings would have grown into agronomically healthy plants in the field. Two-year field trials are being conducted on damaged seeds under field conditions at the University of Illinois at Urbana-Champaign. Further research on additional cultivars with various qualities, under different substrate conditions, or on field trials with various damage scenarios will also improve the understanding of seedling growth patterns of damaged seeds.

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Referee Study Results on Germination of Canarygrass

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Introduction:

Seed Science and Technology Section (SSTS) of Canadian Food Inspection Agency (CFIA) organized a referee study of seed germination on canarygrass (Phalaris canariensis L.) in AprilMay, 2023. A referee study is to evaluate testing methods, i.e., ISTA, AOSA, and Canadian Methods and Procedures for Testing Seed (Canadian M&P). A referee study is also used for studying the uniformity among participating laboratories and providing information for method improvement or harmonization.

It is noticed that the three testing rules, ISTA, AOSA and M&P, have different germination testing temperatures and counting days required for the germination of canarygrass (Table 1).

Table 1. Comparison of the germination method for canarygrass in three testing rules

Rule	Substrata	Temperature (°C)	First count (Days)	Final Count (Days)	Fresh or Dormant Seeds
M&P	BP; RT	15-25	7	10	Prechill, 0.1% KNO_3
ISTA	TP	20-30; 15-25	7	21	KNO_3; Prechill
AOSA	B; T	20-30	3	7	

The Objectives of this Canarygrass Referee Study are:

To promote uniformity among seed testing rules regarding the germination testing temperatures and counting days in canarygrass.

To provide data as supporting evidence for proposing seed testing rule amendments, such as the harmonization of seed testing procedures and rules of AOSA, ISTA and Canadian M&P.

Materials and Method

Testing Samples

A pre-test was conducted to select seed lots based on germination range. In total, germination of nine seed lots of canarygrass were tested and compared under 20-30 °C (Figure 1). Three seed lots (lot 2, 4 and 8) with germination range between 74-88% were selected for this referee study.

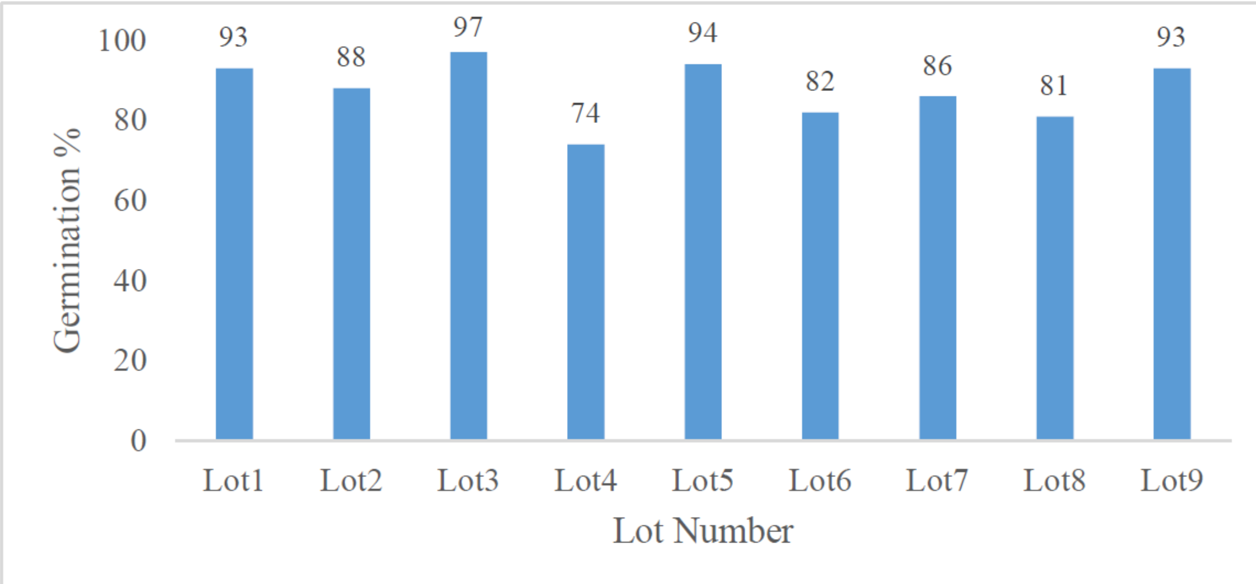


Figure 1. Pre-test germination results of 9 seed lots of canarygrass in 20-30 °C.

Each selected seed lot was mixed and divided into the required subsamples following the Canadian M&P procedures. The homogeneity test samples were randomly assigned, and the tolerance was calculated following ISTA PT program in sample preparation. When the seed lots passed the homogeneity test, subsamples were assigned randomly to 28 participating laboratories in Canada and the USA. Each subsample contained approximately 2000 units of pure seeds, corresponding to approximately 13.5 g (AOSA Rules Volume 1, Table 2A, 150 seeds per gram). This quantity ensured there were enough pure seeds in the subsample for all the required germination tests and re-test if necessary.

Testing Methods

For this referee study, the germination method for canarygrass was conducted as indicated in Table 2. Seed germination was counted and recorded in 3, 7, 10, 14 and 21 days after planting in the provided datasheet. Seedling evaluation followed either the Canadian M&P or AOSA rule. No dormancy treatment was applied.

Table 2. Germination method for the seeds of Phalaris canariensis

Treatments	**Number of seeds x reps**	**Substrata**	**Specific requirement**
Alternating 15 - 25°C	100 x 4	BP/B*	light
Alternating 20 - 30°C	100 x 4	BP/B*	light

* Between paper (BP) substrata is following the Canadian M&P Rule; Between blotters (B) substrata is following the AOSA Rule.

Data analysis

Significant difference between the two germination temperatures and among five counting dates in normal seedlings, abnormal seedlings and ungerminated seeds was evaluated using Generalized Linear Model (GLM) in SAS software at 95% confidence level, with seed lot and temperature as fixed effects and laboratory and replicate as random effects. Analysis of Variance (ANOVA) was conducted to detect the variation sources. Comparison of means between germination temperatures and among counting days were generated.

Data of normal and abnormal seedlings and ungerminated seeds were analyzed using software ISTAgermMV in R package following statistical tools "Inter laboratory tests using ISO 5725-2" developed by ISTA statistical committee. Repeatability and reproducibility were calculated with ISTAgermMV program, where repeatability quantifies the average variability of results within a laboratory, and reproducibility quantifies the average variability among laboratories.

Testing result variation of final germination in each participating laboratory was also analyzed using z-scores, which compare the distance of the participants' results from the overall sample mean of all participants under each temperature for each seed lot.

Test Results

Analysis of Variance and the Effect of Germination Temperature

The analysis of variance for temperature and seed lot effects under different counting days

(Table 3) indicated that temperature did not have significant effect on normal seedlings from day 7 and onwards. Abnormal seedlings were also not significantly affected by the germination temperatures. Seed lots had significant effect on normal and abnormal seedlings in all different counting days, which demonstrates designed variation of seed lots.

Table 3: Analysis of variance of temperature and seed lot effects in different final counting days for canarygrass.

				Normal Seedling		Abnormal Seedling
		Day 7	Day 10	Day 14	Day 21	Day 21
Source	DF	**Pr > F**	**Pr > F**	**Pr > F**	**Pr > F**	**Pr > F**
Temp	1	0.2346	0.8160	0.6003	0.2843	0.3780
Seed lot	2	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Temp*seed lot	2	0.2956	0.0101	0.0288	0.0724	0.0005

The Effect of Counting Days

The germination trends of canarygrass were similar among the three tested seed lots (Figure 2I) and between the two tested germination temperatures (Figure 2II). Overall, germination percentage increased rapidly until day 7, and then slowed down after day 10 and stopped increasing after day 14. Averaged germination percentage did not differ significantly from day 10 (Figure 3).

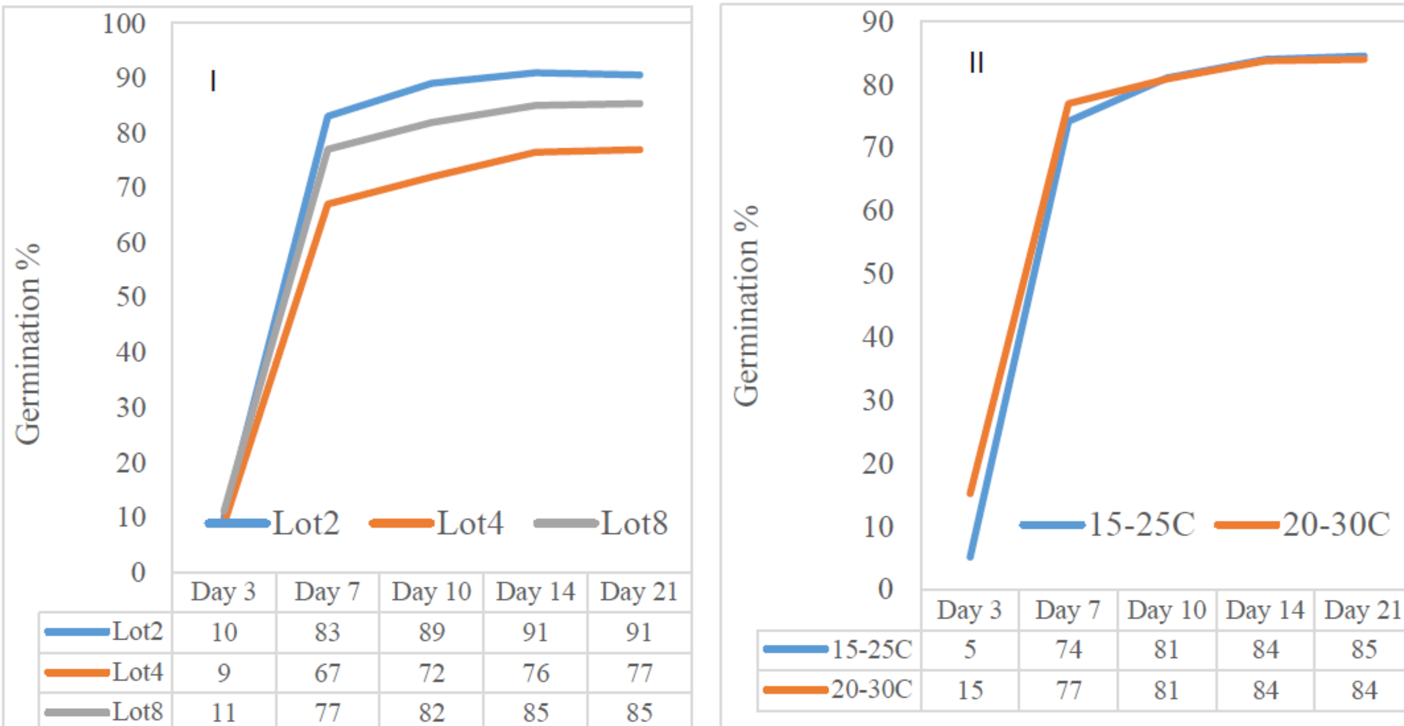


Figure 2. Average germination curve in different counting days in three canarygrass seed lots (I) and under 15 -25 and 20-30^{o}C (II).

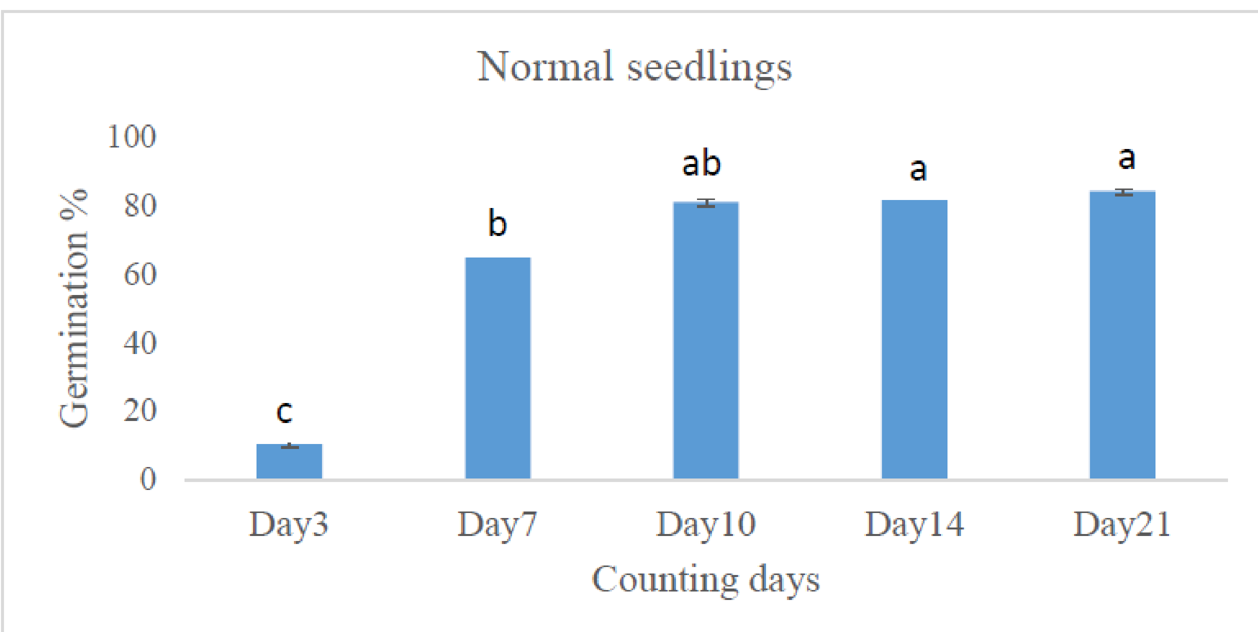


Figure 3. Average germination percentage over three seed lots and two germination temperatures at 5 different counting days.

Repeatability and Reproducibility

Repeatability of canarygrass indicated more variation when seeds were germinated in 20-30°C than in 15-25°C when the seedlings were counted at day 7 and day 10, however, the variations within labs were similar between the two temperatures when counted at day 14 and 21 (Figure 4). The dispersal factors were both around 1.0 (data not shown) for seedlings in both temperatures counted at day 14 and 21.

The reproducibility indicating the variation among laboratories was much higher in 15-25°C when counted early at day 7 and day 10, but the variations got smaller between the two temperatures when the seedlings were counted at day 14 and 21, even though the variation was still higher in 15-25°C (Figure 4).

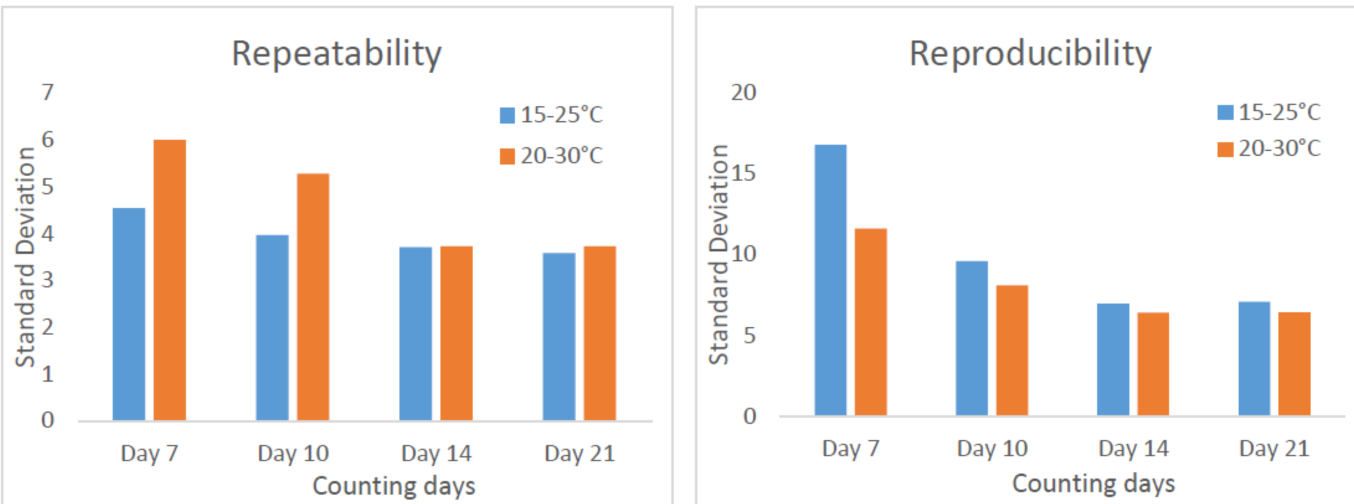


Figure 4. Repeatability and reproducibility of canarygrass seeds germinated in 15-25°C and 2030°C and counted at day 7, 10, 14 and 21.

Performance of Participating Laboratories

The performance evaluation is based on the sum of absolute values of z-score and other parameters for the three seed lots (Appendix 1). This is the feedback to participating laboratories comparing to peer labs for testing uniformity. See Appendix 2 for more details.

The performance rating of the laboratories based on sum of z-scores at each germination condition was displayed in Figure 5. Overall, the performance in the A and B rating categories was between 89 and 96 % over four germination conditions. The lower performance results (C rating) were treatment-specific, e.g. germination under 15-25°C had higher C ratings (11%).

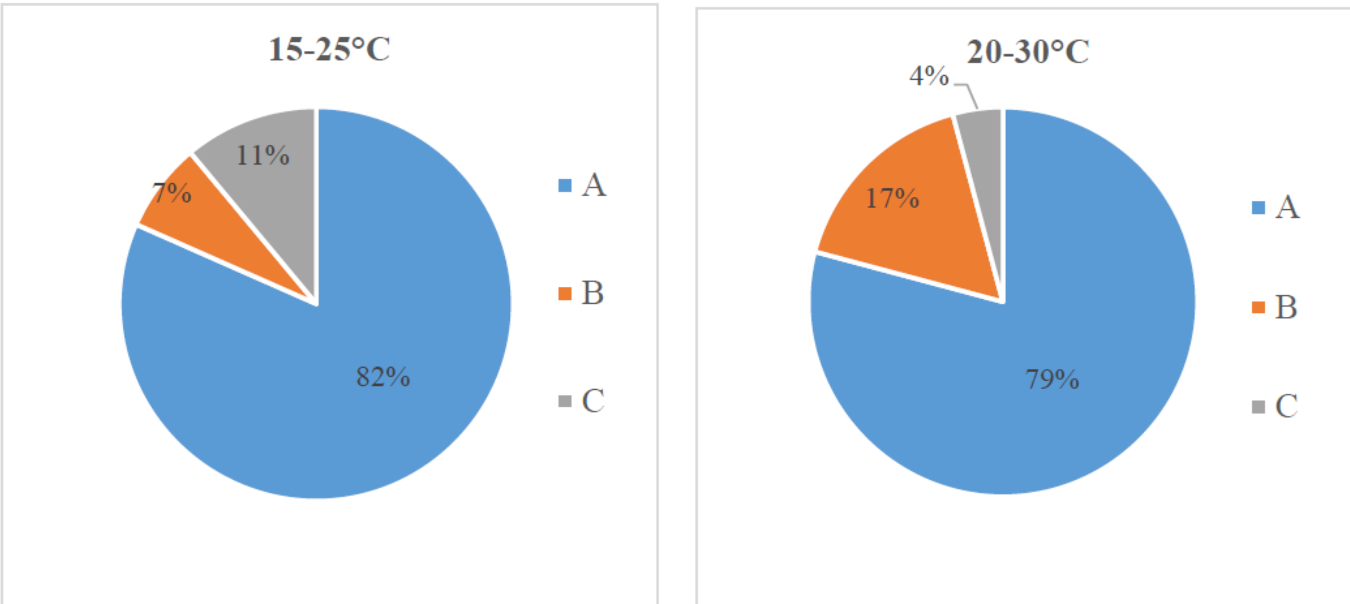


Figure 5. Percentage distribution of overall performance rating over 28 laboratories at two temperature germination conditions. The performance rating is based on sum of z-scores.

Summary and Conclusion

Current M&P has 15-25°C as required germination regime for canarygrass, AOSA has 20-30°C while ISTA has both temperatures listed in the rule. This study indicates the germination of canarygrass was not significantly different between the two germination temperatures from day 7 (Table 3). For the counting days (Table 1), the referee result indicated germination percentage had no significant difference from day 10 (Figures 2 and 3). The comparison of repeatability and reproducibility between the two germination temperatures also showed that the variation within labs and among labs were similar when the seedlings were counted at day 14 and day 21, but not earlier (Figure 5). These results provided supporting evidence for day 7 as the first counting day and day 14 as the final counting day, and both temperature regimes (15-25°C and 20-30°C) for canarygrass. This result and support evidence can be used in testing Rule harmonization and amendment.

Appendix 1. Category standards used for performance evaluation.

Σ absolute z-Score	Performance rating	Feedback Action Suggestions
0.00 – 3.49	A	Acceptable, no action needed.
3.50- 5.29	B	Review of methods is recommended.
5.30 – 6.99	C	Lab should investigate possible problem
> 6.99	D	Lab should investigate possible problem. It is Below Minimum Performance of expected as Canadian or ISTA accredited laboratory

a. Z-score. The Z-score compares the distance of the participant's result from the overall sample mean to the average difference from the mean of all participants. A Z-score of zero indicates the participant's result equaled the overall mean. A high number indicates the participant's result was far away from the mean.

b. Bias. The bias is the average Z-score for a lab and is an indicator of a systematic error which is causing results to be consistently high or low. A value of zero indicates no bias. As the value gets farther from zero the possibility of a bias towards high or low results increases. No significant value has been identified, but a value greater than **1.5** (ignoring the sign) should cause a lab to review its procedures.

c. Precision. Precision is a measure of consistency. A lab which has consistent results will have a low precision value, regardless of how far from the mean these results are. A low precision value indicates consistent performance, while a high value indicates variable performance.

d. Accuracy. Accuracy, as used here, is a combination of bias and precision. Low values indicate the lab is consistently near the overall mean. Increasing values indicate that the lab has a bias in one direction and/or is inconsistent. A value greater than **1.5** is cause for concern; a value greater than **2.0** is an indication that the lab may have a serious problem.

Appendix 2: Evaluation of results for three seed lots from participating laboratories under each of two germination temperatures.

Lab number	Performance parameter				Performance evaluation
	Bias	Precision	Accuracy	Z-score	
			15-25 °C		
1	-0.25	0.25	0.35	0.88	A
2	-0.44	1.43	1.50	3.59	B
3	-1.01	0.45	1.10	3.02	A
4	0.35	0.23	0.42	1.04	A
5	-1.49	0.95	1.77	4.48	B
6	0.39	0.18	0.43	1.18	A
7	0.14	2.29	2.29	5.89	C
8	0.95	0.81	1.25	3.18	A
9	-0.57	0.21	0.61	1.71	A
10	-0.30	0.26	0.40	0.91	A
11	0.17	0.27	0.31	0.91	A
12	0.26	0.60	0.66	1.94	A
13	-2.10	0.76	2.24	6.31	C
14	-0.07	0.34	0.35	0.89	A
15	0.88	0.34	0.95	2.65	A
16	-0.12	0.29	0.32	0.69	A
17	-0.81	0.82	1.15	2.93	A
18	0.33	0.37	0.49	1.23	A
19	-0.08	2.39	2.39	6.16	C
20	0.58	0.19	0.61	1.74	A
21	0.16	0.12	0.20	0.50	A
22	0.23	0.14	0.27	0.69	A
23	-0.50	0.72	0.87	2.12	A
24	0.73	0.08	0.73	2.18	A
25	0.50	0.24	0.56	1.51	A
26	-0.34	0.22	0.41	1.03	A
27	0.39	0.16	0.42	1.16	A
28	0.44	0.18	0.48	1.33	A

Lab number	Performance parameter				Performance evaluation
	Bias	Precision	Accuracy	Z-score	
			20-30 °C		
1	1.03	1.26	1.63	4.53	B
3	-0.85	0.55	1.01	2.56	A
4	-0.28	0.35	0.45	1.16	A
5	-1.39	1.08	1.76	4.20	B
6	0.11	0.57	0.58	1.43	A
7	-0.05	2.31	2.31	6.03	C
8	1.08	0.89	1.40	3.23	A
9	-0.81	0.74	1.09	2.42	A
10	0.78	0.44	0.89	2.33	A
12	-0.60	0.33	0.68	1.79	A
14	0.44	0.38	0.58	1.32	A
15	0.59	0.30	0.66	1.76	A
16	-0.20	0.31	0.36	1.03	A
17	-1.19	0.56	1.32	3.56	B
18	-0.02	0.68	0.68	1.90	A
19	-1.64	1.12	1.99	4.92	B
20	0.37	0.31	0.49	1.24	A
21	-0.13	0.15	0.20	0.43	A
22	-0.14	0.39	0.41	1.09	A
23	-0.20	0.55	0.59	1.63	A
24	0.27	0.28	0.39	0.93	A
25	0.23	0.60	0.64	1.63	A
26	-0.46	0.69	0.83	2.38	A
27	0.11	0.56	0.57	1.47	A
28	0.71	0.18	0.73	2.13	A

Mystery Seed Identification

Jessica Blake, RST, CSA; Quinn Gillespie, RST

Photos courtesy Jessica Blake, ISU

Members who attended the annual meeting gathered around an unknown seed at the Seed Issues Forum and social hour. Jessica Blake, ISU, brought in a small sample of an unknown seed. Members had the opportunity to examine the seed using a variety of tools. The representative from Tagarno set up a display so analysts could zoom in on the unknown seed. Many analysts came with hand lenses after participating in the ISMA seed ID training session during the Teaching and Training Committee meeting. Even still, the group answers varied quite a bit, from spinach to some kind of Boraginaceae. The sample was submitted treated, which also complicated the identification process.

After returning to the lab, Jessica was able to dissect the unknown seeds to have a look at the embryos. This is a tool often used by analysts when positive identification proves challenging. Jessica received the sample shortly before the annual meeting and was not able to dissect the seeds before traveling. After removing the woody pericarp and extracting the endosperm, Jessica was able to isolate an extremely flat, spatulate embryo inside, typical of Euphorbiaceae. This allowed Drew Miller, also of ISU, to scour various resources to find a final identification as *Chrozophora tinctoria.* Excellent seed-sleuthing by the team at ISU!

So, what is *Chrozophora tinctoria*? Currently this plant is in production as an oilseed with potential as a biodiesel fuel source. (Hosini et al.) However, its history with humans goes back hundreds of years. The shells of *Chrozophora tinctoria* seeds were used in medieval illuminated manuscripts to produce some of the most elusive colors in natural pigments- blues and purples. The molecular structures of the colors were identified and matched the colors produced when the shells of C*hrozophora tinctoria* were processed according to instructions written back in the 12th century. (P. Nabais, et al.)

For anyone who ended up stumped on the identification of this seed, don't feel too badly, it's been confounding analysts and art historians for centuries!

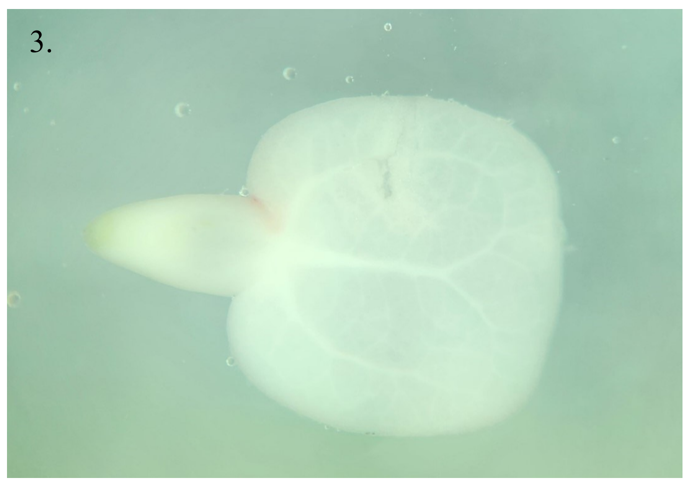
Hoseini SS, Najafi G, Moazzez AF, Hazrati S, Ebadi MT, Yusaf T. Potential of Chrozophora tinctoria Seed Oil as a Biodiesel Resource. Applied Sciences. 2020; 10(10):3473. https://doi.org/10.3390/app10103473

P. Nabais et al. ,A 1000-year-old mystery solved: Unlocking the molecular structure for the medieval blue from Chrozophora tinctoria, also known as folium.Sci. Adv. 6, eaaz7772(2020).DOI:10.1126/sciadv.aaz7772

J. G. Hawthorne, C. S. Smith, Theophilus on Divers Arts: The Foremost Medieval Treatise on Painting, Glassmaking and Metalwork (Dover Publications, 1979), pp. 38–40.

Isolating a Mystery Seed

Photos: Jessica Blake, ISU



From top:

1. An array of Chrozophora tinctoria seeds with mm scale; seed was originally coated. Two decoated seeds to the right.
2. Endosperm removed from seed coat.
3. Embryo excised from endosperm.
4. Flattened, spade-shaped endosperm, typical of Euphorbiaceae helped to narrow down the search.

Golden Pennycress—For Analysts

Botanical Name:
Thlaspi arvense

Common Name(s):
fanweed; Frenchweed; field pennycress

Additional production Name(s):
CoverCress®; Golden Cress

Identification:
CoverCress® seeds very closely resemble wild types of *Thlaspi arvense* in size, texture, and shape, with the notable difference of being a golden-straw color. Seeds are 1.5-2mm in length, slightly ovoid, and laterally flattened with a distinctive “thumbprint” pattern of raised ridges forming a whorl on either sides. Seeds may have a slight peg at the point of attachment.

Wild pennycress. Photo credit: Steve Hurst. Provided by ARS Systematic Botany and Mycology Laboratory. United States,

Golden pennycress: Photo credit, Quinn Gillespie, Universal Seed LLC.

Testing Methods:
Cultivated pennycress does not yet have any official testing methods in the AOSA Rules. *Thlaspi arvense* does have several methods listed in database of species without rules, available on the Analyzeseeds.com website.

Field PennyCress

Domesticated PennyCress

Photo credit: CCI, 2024.

Sample Weights:
CoverCress® does not have any weights listed in Table 2A. Analysts should use the procedures in section 13 of the AOSA Rules, or the Working Weight Calculator available on the Purity Subcommittee page of the website to determine correct purity and noxious weights for each sample.

Germination Methods:
When conducting preliminary testing on this new crop analysts have achieved good results using KNO3, on top of blotters, at 20-30°C, making a first count at 4 days and a final count at 10 days. Additional notes call for light during the test period.

Kind	Substrate	Temperature (°C)	First count	Final count	Fresh and Dormant seed, notes
Thlaspi arvense;	S	15-30	4	10	Light
Pennycress	B	20-30		10	KNO3
	P(a)	20-30			Light
Germination methods listed in Species Without Rules—revised 6-2020					

Seed Identification of Cultivated and Wild Vetches (Vicia spp.)

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The Vicia genus includes approximately 190 species, including the commercially important faba bean (Vicia faba L.) and various cultivated and wild vetches (Vicia L. spp.) 14. The Vicia genus belongs to the Fabaceae family and more specifically, it is a member of the tribe Fabeae of the Faboideae subfamily, a tribe including other agriculturally important genera such as Cicer, Lens, Lathyrus, and Pisum 5,11. Cultivated vetches are used as forage and their ability to fix nitrogen makes them popular as cover crops 10, 12, 3, 5. Vicia sativa L. subsp. sativa is the most common of the cultivated vetches globally 14, with its ability to withstand drought and marginal lands making it an appealing forage crop during climate change 4. Although seeds of V. sativa subsp. sativa contain cyanogenic glycosides that are toxic to humans 1, there is renewed interest in developing a nontoxic form for use as a protein rich pulse crop 4. Cultivated vetches, such as Vicia villosa Roth. and Vicia sativa sub. sativa may sometimes be invasive with their twining growth habit forming dense mats which impede the harvest of various crops 1.

This guide illustrates seed features useful for separating Vicia species listed on the AOSA Exam and the CFIA Minimum List, as well as some of the more common wild vetch species found in Canada and the United States 2, 13. To the untrained eye, the seed of vetch species can look very similar, but there are differences, some subtle and others more obvious. The key features to focus on when identifying vetch species are the following: hilum size, shape, and colour; lens position and prominence; the presence of tissue (funiculus) on hilum; and seed size, shape, and colour. The Vicia species in this poster's scope mostly have a smooth surface texture or are minutely pitted under high magnification. Another closely related genus, Lathyrus, sometimes have similar looking seeds and are known as peavine or vetchling 12. There are over 180 Lathryus species worldwide 6 and are mentioned here for awareness. The Lathyrus genus has some species with seeds with obvious textured surfaces, but some may be smooth and possibly confused with Vicia species.

Cultivated Vetches

Vicia benghalensis L.

Common names: purple vetch, Algerian vetch, vesce de Bengale

Synonyms: *Vicia atropurpurea* Desf.

Identification Tip: lens 1.2 mm from hilum [9]; linear hilum is 2.5 to 3 mm long [10] and covered by persistent white funicular tissue, but may be absent [10]; seed is oval, dull, black, and 4 – 5 mm in diameter [8]

[Top left] Funicular remnant is persistent and stands out irregularly from the hilum.

[Bottom left] Black seeds may appear almost chalky and dull.

Vicia pannonica Crantz

Common names: Hungarian vetch, vesce de Hongrie, vesce de Pannonie

Identification Tip: lens located on opposite side of seed as hilum; hilum 2 mm long [10] and narrowly oblong; seed compressed and lenticular or cone-shaped; seed 4.0 to 4.5 mm long [10]; brown with darker mottling, but some may be greenish grey with mottling [7]. Beware of other Vicia species with lens on opposite side: *V. hybrida L., V. lutea L., V. melanops* Sm.

[Top and rightmost seed, bottom] Lens position opposite the hilum.

Seed may be slightly glossy and irregularly shaped.

Vicia sativa L. *subsp. sativa*

Common names: common vetch, vesce cultivée, cultivated vetch, tare

Identification Tip: lens is pronounced and near hilum end; hilum is 2.0 to 2.5 mm long [10], narrow, oblong or wedged-shaped; seeds are generally large in comparison to other Vicia species in guide's scope; seed colour ranges from yellow to brown with dark mottling; seed radicle is a longer triangular shape than *V. villosa.*

[Top] Dark mottled and yellow Vicia sativa subsp. sativa seeds.

[Center left] Yellow seeds with prominent lens clearly visible.

[Bottom left] Intact Common vetch seed and seed with seed coat removed to show elongated triangle shape of radicle.

Vicia villosa Roth

Common names: hairy vetch, fodder vetch, vesce velue, woolly-pod vetch

Identification Tip: lens near hilum end; hilum is small compared to seed size, generally a similar colour to the seed coat, and is short oblong or wedge-shaped; depending on subspecies, may be spherical (rolls easily) or oval; seed size variable and may be similar to *V. sativa subsp. sativa* in size and shape; seed is generally dull, black or dark brown; seed radicle is a broad triangular shape compared to the longer radicle of *V. sativa subsp. sativa*

[Top] Seed showing both oblong and wedge shaped hilums.

[Center left] Seed of various sizes. Hilums may be lighter in color (above) or the same color as the rest of the seed coat (left)

[Bottom left] Slightly mottled seed and a seed with seed coat removed to show broad triangular radicle.

Wild Vetches (*Vicia* spp.)

Vicia americana Muhl. ex Willd.

Common names: American vetch, buffalo-pea, vesce d'Amérique

Identification Tip: lens 1.3 to 2.0 mm from hilum[9]; hilum is 3.5 mm long[10], relatively wide and a lighter colour than seed coat, but may be same colour; seeds are reddish or dark brown, mottling is obscure if present [10]; relatively small, and is spherical or conical; seed similar to *Vicia cracca*

[Top] Seeds showing wide, pale hilums with pronounced dark line down the center.

[Bottom] Seed of variable sizes, showing dark hilum and position of lens.

Vicia cracca L.*

Common names: tufted vetch, bird vetch, vesce jargeau

Identification Tip: lens 1.0 mm from hilum[9]; hilum is 2.5 to 3.0 mm long[10] and wide with a light, thin strip in its middle, seed is dull, dark brown, black or lighter colour and mottled; relatively small in size but it is variable and is oval, spherical, conical or oblong; seed similar to *Vicia americana*

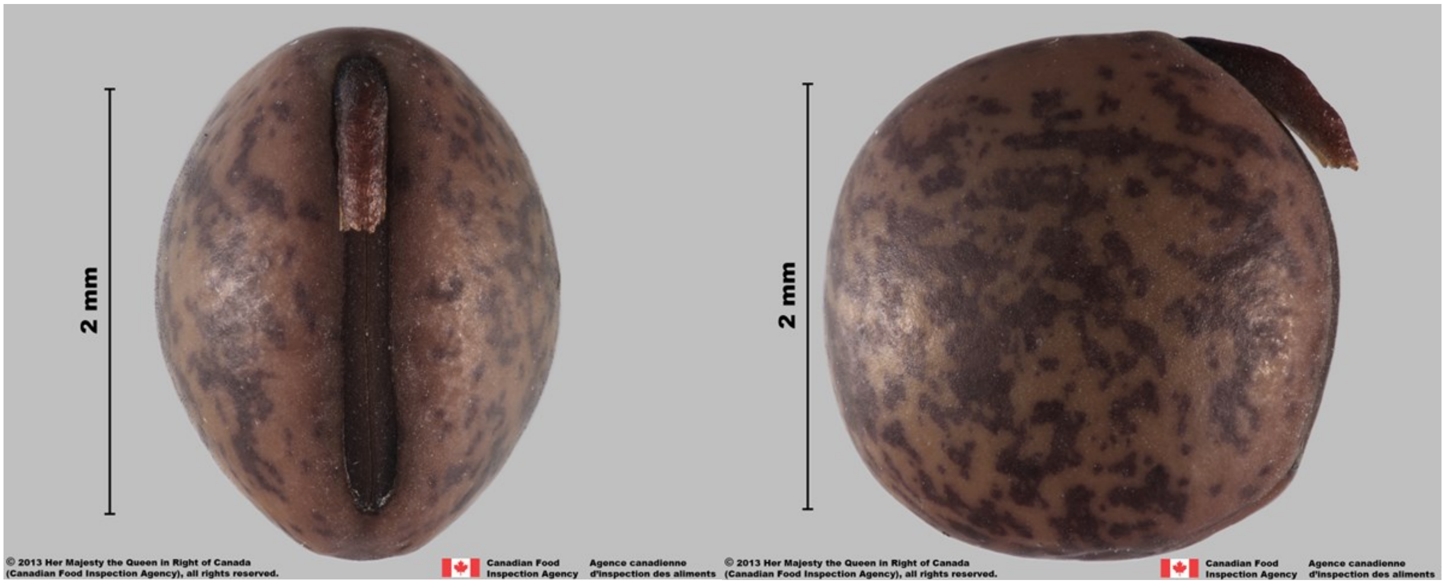
Pale strip down the middle of the hilum visible on dark colored seeds [Top]
Mottled seed with lens visible on lighter-colored seed. [Bottom]

**For analysts conducting an All-Staes Noxious Exam, Vicia cracca is the only Vicia sp. considered noxious. It is listed as restricted in Alaska as of the January 2024 update to All-States Noxious Weed Seed list provided by USDA-AMS.*

Vicia hirsuta (L.) Gray

Common names: tiny vetch, hairy tare, hairy vetch, vesce hérissée

Identification Tip: lens is 0.6 to 1.0 mm from hilum [9]; hilum long, narrow and may be covered or partially covered with funicular tissue; seed is glossy, light brown or reddish brown colour, which may be due to age [9], that is almost solid or with darker mottling; relatively small and lenticular, oval shaped



[Top] Mottled seeds with persistent funicular tissue visible.

[Bottom] Comparison of mottled and dark brown seeds. Like many other Fabaceae, seed may darken with age. Bottom leftmost seed shows distinctive "coin-purse" shape.

Vicia sativa L. subsp. nigra (L.) Ehrh.

Common names: narrow-leaved vetch, black-pod vetch, vesce noire

Synonym: Vicia angustifolia L., Vicia sativa var. angustifolia (L.) Wahlenberg

Identification Tip: lens more obvious on lighter coloured seeds and located near narrow end of hilum; hilum is wedge-shaped and lighter in the middle than the outside; seeds are brown with dark mottling but some a lighter colour, 3.0 mm in diameter 1, and spherical, oval or cylindrical

[Top] Solid-colored and mottled seeds with wedge-shaped hilums visible. Coloring may be similar to Vicia hirsuta.

[Bottom] Seed showing wedge-shaped hilum, paler toward the center and lens visible on light-colored seed.

Vicia sepium L.

Common names: hedge vetch, bush vetch, vesce des haies

Identification Tip: hilum is linear, thin and is the longest of the species in this guide's scope as it is half of the seed's circumference or greater, most seeds only have a tiny piece of the long funiculus remaining; seed greenish brown, light to dark brown with darker mottling or may be a solid colour; seed relatively small; seed is oval, spherical, or lenticular

[Top] Seeds showing narrow, elongated hilum. Seeds range from light orange with dark mottling, to medium brown, to terra cotta colored.

[Bottom] Seeds with and without funicular remnant attached.

Vicia tetrasperma (L.) Schreb.

Common names: four-seeded vetch, lentil vetch, vesce à quatre graines, sparrow vetch (AOSA)

Identification Tip: lens is prominent and 0.4 mm from hilum[9]; hilum's outline is ridged, hilum is short at 1.25 mm 10, oblong shaped, and is lighter in its middle; seed spherical, lenticular or oval and is the smallest Vicia species in guide's scope at 1.5 to 2.5 mm in diameter[1]

[Top] Darker brown and green mottled seeds with oblong hilums which pale toward the center.

[Bottom] Selection of small Vicia tetrasperma. Lens may be more readily visible on lighter colored seeds.

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Seed Identification Reference List

Prepared by D. J. Lionakis Meyer, 2024

Included here are a few valuable resources for seed identification. This is not a comprehensive list but is a good place to start on your quest for seed identification information. Additionally, local and regional floras from all over the world often contain valuable information about fruit and seed descriptions. There are too many to list here, but many are available as books, journal articles, and online websites. If purchase is not an option for you, be sure to check your local university libraries for the books and journals listed. Not all resources are published in the English language, but you can easily use online translation programs to translate to English or any other language of your choice. Good luck with your search for answers.

Books:

Barkworth, M. E., K. M. Capels, S. Long, and M. B. Piep. 2003. Flora of North America. Vol. 25. Magnoliophyta: Commelinidae (in part): Poaceae, part 2. Oxford University Press. 783 pp. http://floranorthamerica.org/Poaceae or http://floranorthamerica.org/Volume_25 [Excellent line drawings of whole grass plants and detailed floral structures; sufficient in many cases to assist in identification of grass seed units.]

Barkworth, M. E., K. M. Capels, S. Long, L. K. Anderton, and M. B. Piep. 2007. Flora of North America. Vol. 24. Magnoliophyta: Commelinidae (in part): Poaceae, part I. Oxford University Press. 911 pp. Hard copies available for purchase or digital versions available online at http://floranorthamerica.org/Poaceae or http://floranorthamerica.org/Volume_24 [Excellent line drawings of whole grass plants and detailed floral structures; sufficient in many cases to assist in identification of grass seed units.]

Baxter, D. and L. O. Copeland. Seed Purity and Taxonomy. 2008. Michigan State University Press. 719 pp. [Contains seed descriptions and illustrations grouped by family.]

Bojňansky, V. and A. Fargašová. 2007. Atlas of Seeds and Fruits of Central and East-European Flora: the Carpathian Mountains Region. Springer.1046 pp. [Nearly 4,800 excellent line drawings and detailed seed/fruit descriptions.]

Bonner, F. T., R. P. Karrfalt, (eds.). 2008. The Woody Plant Seed Manual. Agriculture Handbook 727. United States Department of Agriculture Forest Service. https://www.fs.usda.gov/nsl/nsl_wpsm.html or https://www.fs.usda.gov/rm/pubs_series/wo/wo_ah727.pdf [Excellent reference for tree and shrub species with illustrations of internal seed/fruit morphology and black and white images of seeds]

Bryson, C. T. and M. S. DeFelice (eds.). 2009. Weeds of the South. University of Georgia Press. 468 pp. [More than 1,500 full-color photographs (seed photos included for most species), diagnostic descriptions and distribution information on 400 of the most troublesome weedy and invasive plants found in the southern United States.]

Clark, L. G. and R. W. Pohl. 1996. Agnes Chase's First Book of Grasses: The Structure of Grasses Explained for Beginners. 4th ed. Smithsonian Institution Press. 127 pp. [Excellent well illustrated publication to assist

with understanding grass floral structures – highly recommended for anyone new to grass identification.]

Cornejo, F. and J. Jonovec. 2010. Seeds of Amazonian Plants. Princeton University Press. 155 pp. [Covers 544 genera and 131 families of Amazonian plants and includes 750 color photographs and seed identification key.]

Davis, L. W. 1993. Weed Seeds of the Great Plains: A Handbook for Identification. University Press of Kansas. 145 pp. [Information about the seeds of 280 species of weedy plants of the Great Plains, including ones commonly found in crops, rangeland, lawns, and along roadsides. Includes 600+ photographs and drawings.]

Delorit, R. J. 1970. Illustrated Taxonomy Manual of Weed Seeds. Available at www.amazon.com. [Color photographs of seeds]

Delorit, R. J, and C. R. Gunn. 1986. Seeds of Continental United States Legumes (Fabaceae). Agronomy Publications. 134 pp. [Morphology definitions, table of contents separated by morphological features, each page has four seed kinds and the other page has great in color pictures of those seeds. Available to purchase on Amazon at: https://www.amazon.com/Continental-United-States-Legumes-Fabaceae/dp/0961684704]

DiTomaso, J. M. and E. A. Healy. 2003. Aquatic and Riparian Weeds of the West. University of California Agriculture and Natural Resources Publication 3421. 442 pp. [Comprehensive identification manual for aquatic and riparian weeds west of the Rocky Mountains. Includes full descriptions of 82 species representing 42 plant families (also provides information on another 96 species compared as similar species). Contains 560+ color photographs of plants and in many cases seeds. Currently out-of-stock at the UC Davis Bookstore but used books may be found on Amazon.]

DiTomaso, J. M. and E. A. Healy. 2007. Weeds of California and Other Western States. Vol. 1: Aizoaceae – Fabaceae and Vol. 2: Geraniaceae – Zygophyllaceae. University of California Agriculture and Natural Resources Publication 3488. 1 – 834 pp. [A 2-volume set arranged alphabetically by family. Includes full descriptions of 450+ weed species and another 360+ plants compared as similar species, representing 63 plant families. Color photographs of over 700 species including seeds, seedlings, flowers, and mature plants. Available for purchase at https://anrcatalog.ucanr.edu/Details.aspx?itemNo=3488]

Elpel, T. J. 2013. Botany in a DayAPG: The Patterns Method of Plant Identification, An Herbal Field Guide to Plant Families of North America. 6th Ed. HOPS Press, LLC, Pony, MT. [A fun and easy to follow guide to identification of plant families and genera. Beautiful color illustrations of representative family members. Great resource for beginners. Available for purchase online.]

Flora of North America, numerous hard copy volumes for various families are available, but can also be accessed online at http://floranorthamerica.org/Main_Page [See previous comments under Barkworth et al.]

Heywood, V. H., R. K. Brummitt, A. Culham, and O. Seberg. 2007. Flowering Plant Families of the World. Firefly Books. [Excellent for general family plant, fruit, and seed descriptions as well as economic uses. Available for purchase online].

Hillman, F. H. and H. H. Henry. 1935. Photographs of Drawings of Seeds; The More Important Forage-Plant Seeds and Incidental Seeds Commonly Found With Them. Division of Seed Investigations, Bureau of Plant Industry, United States Department of Agriculture, Washington

D.C.. Revised 1935. https://frontrangeseedanalysts.weebly.com/usda-plates.html [Excellent illustrations; note the scientific names may be out-of-date.]

Hitchcock A.S. 1971 Manual of the Grasses of the United States. (2nd Ed., revised by A. Chase). Dover Publications. [Now published as a two-volume paperback set. Very good dichotomous key with illustrations when you ID down to the genus and species level. Available for purchase on Amazon at: Volume 1 https://www.amazon.com/Manual-Grasses-United-States-1/dp/0486227170 and Volume 2 https://www.amazon.com/Manual-Grasses-United-States-2/dp/0486227189]

Hurd, E. G., S. Goodrich, and N L. Shaw. 1997. Field Guide to Intermountain Rushes. U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report INT-306. [Includes diagnostic descriptions, line drawings, black and white and color photographs of each species. Available for free download at https://www.fs.usda.gov/research/treesearch/24234]

Hurd, E. G., N L. Shaw, J. Mastrogiuseppe, L. C. Smithman, and S. Goodrich. 1998. Field Guide to Intermountain Sedges. U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-10. [Includes diagnostic descriptions and key, illustrations and color photographs of plants and seeds of 112 species of *Carex* from the Intermountain region.]

Jensen, H.A. 1998. Bibliography on Seed Morphology. A.A. Balkema Publ., Rotterdam, Netherlands. 310 pp. [Outstanding compilation of 3775 references focusing on publications containing information useful in seed identification and published before 1990. Unfortunately, this book is no longer in print, so check your local university library for a hard copy. A limited preview of this book is available online at https://books.google.com/books/about/Bibliography_on_Seed_Morphology.html?id=nfudcmH7A8UC]

Jones, S., J. Taylor, and F. Ash. 2004. Seed Identification Handbook: Agriculture, Horticulture & Weeds. 2nd ed. NIAB, Cambridge, UK. 94 pp. [A comprehensive guide to over 200 seeds commonly found in agriculture. Diagnostic descriptions, color photographs, and life-size seed silhouettes provided to aid identification. Available for purchase at https://www.niab.com/news-views/publications-resources]

Lentz, D. L. and R. Dickau. 2005. Seeds of Central America and Southern Mexico: the Economic Species. Memoirs of the New York Botanical Gardens. Vol. 91. The New York Botanical Garden. 297 pp. [Descriptions and black and white photographs of seeds of 503 species from Central American and southern Mexico. Available for purchase at https://www.nhbs.com/seeds-of-central-america-and-southern-mexico-book]

Mabberley, D. J. 2017. Mabberley's Plant-Book—A Portable Dictionary of Plants, Their Identification and Uses. 4th edition. Cambridge University Press. [An authoritative source of information on the approximate number of species and overall geographic distribution of the genera and families of vascular plants of the world, with helpful comments on morphology, economic uses, and biology. Scientific names are arranged in alphabetical order, and quite a few common names are also listed. Available for purchase from a variety of online vendors.]

Martin, A. C. and W. D. Barkley. 1961. Seed Identification Manual. University of California Press. 221 pp. [There are a couple of more recent reprints of this book, but all are basically the same content. Contains 824 black and white photographs of seeds from 600 species encountered in farmlands, wetlands, and woodlands found in various locations in the United States. Available for purchase at https://www.amazon.com/Seed-Identification-Manual-Alexander-Martin/dp/1932846034]

Musil, A. F. 1963. Identification of Crop and Weed Seeds. Agriculture Handbook No. 219. U.S. Department of Agriculture, Washington, D.C. 171 pp. + plates. [Contains diagnostic keys and detailed seed illustrations of many common crops and weed seeds. A classic reference found in many seed labs. It is out-of-print but occasionally copies appear for sale on the internet. A scanned copy is available online at https://www.biodiversitylibrary.org/item/295013#page/184/mode/1up]

Neal, J. C,. R. H. Uva, J. M. DiTomaso and A. DiTommaso. 2023. Weeds of the Northeast. (2nd Ed.) Cornell University Press. 397pp. [Newly revised and expanded to include the Northeast and Mid-Atlantic states with description of weeds, plants, and seeds, every plant has a color image of the plant and there are also images of their seeds. Available to purchase on Cornell University Press at: https://www.cornellpress.cornell.edu/book/9781501755729/weeds-of-the-northeast/#bookTabs=1]

Nesbitt, M. 2006. Identification Guide for Near Eastern Grass Seeds. Institute of Archaeology University College London. 129 pp. [Very detailed descriptions and illustrations of grass caryopses from 122 genera, as well as multi-access diagnostic keys. Available for purchase from various online sources.]

Royer, R. and R. Dickinson. 2004. Weeds of the Northern U.S. and Canada. The University of Alberta Press. 434 pp. [In addition to descriptions plants, fruits, and seeds, there are color images of plants and seeds. Available for purchase at: https://www.amazon.com/Weeds-Northern-U-S-Canada-Identification/dp/1551052210]

Sweedman. L. and D. Merritt. Australian Seeds: a Guide to Their Collection, Identification and Biology. 2006. CSIRO Publishing. 258 pp. [Includes information on seed biology, evolution and morphology, and all aspects of harvesting, processing and storage of seeds, and seed germination requirements for species found primarily in western Australia. Features photographs of more than 1,200 species showing clearly their size and shape. Out-of-print, but available in Kindle format at www.amazon.com]

Lobova, T. A., C. K. Geisclman, and S. A. Mori. Seed Dispersal by Bats in the Neotropics. Memoirs of the New York Botanical Garden. [Has numerous color images of seeds of may tropical species. Available for purchase at: https://nybgshop.org/seed-dispersal-by-bats-in-the-neotropics-mem-101/]

Webb, C. J. and M. J. A. Simpson. 2001. Seeds of New Zealand Gymnosperms and Dicotyledons. Manuka Press. 428 pp. [Describes the seeds, and other persistent parts of fruits, of native New Zealand gymnosperms and dicotyledons and covers 1,058 species, representing 255 genera from 94 plant families. A key and 1,750+ photographs are available to aid seed. Available for purchase at: https://www.manukapress.co.nz/seed_atlas.html]

Young, J. A. and C. G. Young. 1992. Seeds of Woody Plants in North America. Dioscorides Press. 407 pp. [Covers 386 genera of woody plant seeds, including numerous line drawings and black and white photographs that are useful for seed identification. Available for purchase at: https://www.amazon.com/Seeds-Woody-Plants-North-America/dp/1604691123]

United States Department of Agriculture. 1952. Testing Agricultural and Vegetable Seeds. Agriculture Handbook No. 30. [Contains historical information on seed testing procedures, seed descriptions, and excellent illustrations of crop and weed seeds (note the nomenclature may be out-of-date for some species). Available for free PDF download at: https://www.govinfo.gov/app/details/GOVPUB-A-PURL-gpo17393]

Zomlefer, W. B. 1994. Guide to Flowering Plant Families. The University of North Carolina Press, Chapel Hill, NC. [Excellent technical information of plant families, contains hundreds of illustrations, and includes beautifully illustrated botanical glossary. Available for purchase from various online sources].

Journal Articles:

Baskin, C. C. and J. M. Baskin. 2007. A revision of Martin's seed classification system, with particular reference to his dwarf-seed type. Seed Science Research 17:11-20. [Provides a revision to Martin (1946) related to dwarf-seed type embryos and a revised key to seed embryo types. https://www.researchgate.net/publication/231945377_A_revision_of_Martin's_seed_classification_system_with_particular_reference_to_his_dwarf-seed_type. [Does not contain illustrations or photos.]

Baskin, C. C. and J. M. Baskin. 2021. Relationship of the lateral embryo (in grasses) to other monocot embryos: a status up-grade. Seed Science Research 31:199-210.

https://doi.org/10.1017/S0960258521000209

Isely, D. 1947. Investigations in seed classification by family characteristics. Iowa State College Research Bulletin 351:317-380. https://core.ac.uk/download/pdf/128978283.pdf [Descriptions and key for seeds and fruits of various plant families. Numerous illustrations.]

Martin, A. C. 1946. The comparative internal morphology of seeds. The American Midland Naturalist 36:513-660. https://www.jstor.org/stable/2421457 [Excellent foundational paper on seed embryo and endosperm placement within seeds. Line drawings of longitudinal and cross-sectional view of embryo/endosperm placement in 1,287 genera including gymnosperms, monocots, and dicots.]

Terrell, E. E. 1971. Survey of occurrences of liquid or soft endosperm in grass genera. Bulletin of the Torrey Botanical Club Vol. 99(5):264-268. https://www.jstor.org/stable/2483625

Manuals:

SCST. 2018. Seed Technologist Training Manual. Society of Commercial Seed Technologists. [Excellent reference for all aspects of seed testing. Contains the sample illustrations of crop and weed seeds found in Agriculture Handbook No. 30 listed above. Available for purchase at: https://analyzeseeds.com/product/seed-technologist-training-manual-2017/]

Websites:

Australian Centre for International Agricultural Research. Tropical Forages. https://www.tropicalforages.info/text/entities/index.htm [Factsheet on tropical forage species of including images of plants, fruits, and seeds.]

Colorado State University Seed Images. www.seedimages.com [Requires a paid subscription for access.]

Groningen Institute of Archaeology (GIA – RUG) and Deutsches Archäologisches Institut (DAI) – Berlin. 2006. Digital Plant Atlas. https://www.plantatlas.eu/repository [The database of seed and fruit images included in The Digital Plants Atlas of the Netherlands (2006), The Digital Atlas of Economic Plants (2010), and others.]

Front Range Seed Analysts. Seeds of Cultivated Flowers. https://frontrangeseedanalysts.weebly.com/flower-seed-images-frsa-1995.html [Color images of flower seeds from about 54 families. No written seed descriptions.]

International Seed Morphology Association (ISMA). Seed ID Guide. https://www.idseed.org/ [Excellent high resolution seed images and detailed descriptions.]

International Seed Testing Association (ISTA). Purity Committee Universal List of Species

https://www.seedtest.org/en/services-header/tools/purity-committee/universal-list-species.html [Seed descriptions and color images of commonly encountered crop and weed seeds.]

Islam, M., A. Miller, M. Maher, J. Scher, and A. J. Redford. 2022. Fruit and Seed Family ID. USDA APHIS PPQ Identification Technology Program. Fort Collins, CO. https://idtools.org/seed_families/ [This tool currently only covers monocot families (79 families)].

Rancho Santa Anna Botanic Garden Seed Photo Website http://www.hazmac.biz/seedphotoslistfamily.html [Images of native species, no written descriptions.]

Scher, J. L., D. S. Walters, and A. J. Redford. 2015. Federal Noxious Weed Disseminules of the U.S., Edition 2.2. California Department of Food and Agriculture, and USDA APHIS PPQ Identification Technology Program. Fort Collins, CO. https://idtools.org/tools/1031/index.cfm [Excellent high resolution images and seed descriptions.]

South Australian Seed Conservation Centre. Seeds of South Australia. https://spapps.environment.sa.gov.au/SeedsOfSA/home.html [Excellent seed images for many of the species included in the database. Handy for comparison of seed, fruit, and plant images of up to four species at a time.]

The James Hutton Institute Arable Seed Identification System – https://asis.hutton.ac.uk/ [Basic sorting key and color seed images.]

University of Hamburg Collections. The Reference Collection of Bredemann and Nieser from Hamburg. https://www.fundus.uni-hamburg.de/de/collections/loki_schmidt_haus [Excellent color images of seeds. Note: language German.]

USDA, AMS Seed Regulatory and Testing Website. https://www.ams.usda.gov/rules-regulations/fsa

USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Online Database]. https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearch [Nomenclature source for all scientific names found in the AOSA Rules for Testing Seeds. The database also includes color seed images for some species.]

USDA, NRCS. 2015. The PLANTS Database. https://plants.usda.gov/home [Excellent resource for plant distribution in the United States and Canada. Has color seed and plant images for some species. Contains fact-sheet or plant guides for some species, as well as other useful information associated with natural resource conservation.]

Walters, D. S. 2011. Identification Tool to Weed Disseminules of California Central Valley table grape production areas. USDA CPHST Identification Technology Program. https://idtools.org/id/weed-tool/key/index.htm [Excellent high resolution color seed images and descriptions of common weed seeds.]

This list is also available as a separate downloadable PDF from the AOSA-SCST Purity Subcommittee webpage at: https://analyzeseeds.com/wp-content/uploads/2024/05/Seed-Identification-Reference-List-2024-revised-3-22-2024.pdf

Study Guide: Genetic Vocabulary Anagrams

Genetic Technology Committee: Education subcommittee

Solve the anagram using the clues!

1.) YAM SAY MUSKMELON DINITROBENZENES
Typically designated as competitive or antibody sandwich formats

1) ______________________

2.) YO THY CLOP
The part of the stem of an embryo plant beneath the stalks of the seed leaves or cotyledons and directly above the root.

2) ______________________

3.) UNITE TIN HYENINE CYANOGENAMIDES
The four bases in DNA

3) ______________________

4.) LAURIC
Constituent base of RNA

4) ______________________

5.) BAROGRAM CUTIE
A naturally occurring bacterium that is capable of inserting its DNA (genetic information) into plants, resulting in a type of injury to the plant known as crown gall

5) ______________________

6.) UNFUSSY LOREAL
A class of herbicides included in ALS Inhibitors. Examples include chlorimuron, nicosulfuron, and primisulfuron.

6) ______________________

7.) GEOSCIENTIFIC LUR COS
A type of electrophoresis that uses electrical current to separate protein molecules in a gel matrix in which a pH gradient has been established.

7) ______________________

8.) OBESITY CHIRM
The study of chemical processes that comprise living things

8) ______________________

9.) RETRO MOP
The region on DNA to which RNA polymerase binds and initiates transcription

9) ______________________

10.) NINE TAG
Another word for "immunogen"

10) ______________________

Answer Key:
1.ENZYME LINKED IMMUNOSORBENT ASSAY 2.HYPOCOTYL 3.ADENINE THYMINE GUANINE CYTOSINE 4.URACIL 5.AGROBACTERIUM 6.SULFONYLUREAS 7.ISOELECTRIC FOCUSING 8.BIOCHEMISTRY 9.PROMOTER 10.ANTIGEN

Lost Resources

Michael L. Simpson, Illinois Department of Agriculture

Michael Lynn Simpson, 62, of Pawnee, Illinois, passed away Friday, May 3, 2024, in Springfield. He was born Aug. 27, 1961, in Springfield, the son of Harry R. and Margaret L. Wright Simpson Jr. He married Rochelle "Shelley" I. Freitag on March 1, 2024, in Springfield. Michael was preceded in death by his parents and grandparents.

Michael graduated from Pawnee High School in 1979. He worked as a seed analyst at the Illinois Department of Agriculture for more than 30 years. Agriculture was an important part of Michael's life, and he also worked for Boarman Brothers in Pawnee for 29 years. He loved spending time at the lake and was an avid fisherman. Additionally, he was a sports fan, rooting for the Atlanta Braves baseball team and the Florida State Seminoles football team.

He is survived by his wife, Shelley Simpson, of Springfield; one son, Travis M. (wife, Megan) Simpson, of Pawnee; one daughter, Amanda M. (husband, Dominic) Clouser, of Rochester; four grandchildren, Braxton and Tucker Simpson and Renzo and Aria Clouser; one brother, Ed Simpson, of Pawnee; one uncle, Tom (wife, Mona) Simpson, of Pawnee; and several nieces, nephews and cousins.

Michael's family will meet friends from 4 p.m. to 7 p.m. Wednesday, May 8, 2024, at Curry Funeral Home in Pawnee. A funeral service will be held at 10 a.m. Thursday, May 9, at the funeral home, with Rev. A.B. Bennett officiating. Burial will follow at Horse Creek Cemetery in Pawnee.

Memorial contributions may be made to the Pawnee Sports Boosters, P.O. Box 196, Pawnee, IL 62558.

Curry Funeral Home in Pawnee is serving the family of Michael Simpson. Online condolences may be expressed at www.curryfh.com.

Lost Resources

Ethel Ledgerwood, RST, retired

Ethel Viola Ledgerwood Davis passed away of natural causes on February 3, 2024, in Klamath Falls, Oregon, at the age of 104. She was preceded in death by her parents, husband and nine siblings. She leaves behind 11 nieces and nephews and multiple great- and great-great-nieces and nephews. She was born November 29, 1919, in Athabasca, Alberta, Canada, to James Alexander Ledgerwood and Margaret Eliza Keyes.

The family moved to Oregon, where Ethel grew up. She worked at Buchanan Cellers for many years.

She married Howard Martin Davis on December 23,1952. Ethel and Howard loved to travel.
She will be remembered for her quick wit and smile.

Ethel became an RST in 1951 while employed by Buchanan Cellers Grain Company in Oregon. Ethel retired from seed testing around 1986.