Abstracts

from oral and poster presentations
given at the 98th
Association of Official Seed Analysts
and the 85th
Society of Commercial Seed Technologists
(AOSA/SCST)
annual meeting
held in St. Paul, Minnesota on
June 5th–12th, 2008

Methodology to Develop a Uniform Blowing Procedure in Grass Seeds: An Example with Tall Fescue

Adriel Garay*, Sabry Elias and Heather Nott

Uniform Blowing Procedure is a technology that can be used to separate lightweight inert matter in grass seed samples. The benefits of this method have been demonstrated for many years with orchardgrass, Kentucky bluegrass and others. In 2006, the master calibration sample concept and the use of air velocity calibration were incorporated to the AOSA Rules. Based on these new innovations, a systematic research was conducted to develop a uniform blowing procedure for tall fescue. The studies started by finding an optimum blowing point to separate light inert from heavy pure seeds and concluded with a rule proposal to AOSA-SCST as follows:

First, a preliminary blowing point was identified by blowing samples at increasing air velocity points and assessing the blowings visually for presence of caryopsis, using the one third-caryopsis size rule. The planting value of the fractions blown out was evaluated by germination tests. The results led to a preliminary identification of the "location of the optimum blowing point".

Second, the blowing point was validated across a larger number of samples representing different varieties, years, production locations, and seed sizes, using the ⅓ caryopsis size rule. The 100-seed weight of the material blown out and retained portions were measured. Additionally, the germination of the structures blown out and the retained heavy fraction was tested. All these studies made it possible to understand the planting value of the light portion and the retained heavy portion and demonstrated that the blowing point chosen was adequate across the broad range of samples tested.

Third, master calibration samples of proven uniformity were developed. This step is critical because seed laboratories cannot use a blowing procedure unless calibration samples of proven uniformity are available. This step made it possible to have calibrations samples for the referee studies so that all labs can find comparable blowing points in their specific blowers.

Fourth, uniformity across blowers was tested. The first study was conducted in-house using seven blowers and many blind samples. This study was followed by a national referee where labs calibrated their blowers with the "tall fescue master calibration samples" provided to them and used three blind samples with different levels of light inert content. A second national referee was conducted in late 2007 to encourage more participation and familiarization with the new method. Regardless of the amount of lightweight inert present in the blind samples, all labs were able to blow out comparable amounts of light inert. This proved that, the new standard blowing procedure contributes to uniform separation of light inert. As a result, a rule was proposed to the AOSA-SCST to add tall fescue to the list of species that use the blowing procedure.

The stepwise methodology used will be illustrated during the research presentation. The advantages of the new method for testing Tall fescue will be

discussed. The importance of the methodology used to develop blowing procedures for other species will be discussed.

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Better Alternative to Breaking Multiple Seed Units in Tall Fescue

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The AOSA Rules for Testing Seeds treats multiple florets in grasses differently. For example in tall fescue and ryegrasses, it requires the analysts to break them apart manually to estimate the inert and pure seed units, which is time consuming and can create variability. In orchardgrass and fine fescues, it uses the factor method, which is more time efficient and reduces subjectivity. Kentucky bluegrass, which uses a blowing procedure, multiple seed units (MSU's) are left intact. The last option is efficient, eliminates subjectivity, does not change the nature of the sample and the result reflects the true condition of the seed as it is being marketed and planted.

Research was conducted to determine if a better alternative to breaking multiples can be identified for tall fescue. The research included the following steps:

First, the frequency of multiple florets in tall fescue samples was measured using samples from 2006 and 2007 crop years. The results in both years indicated that 96% of samples contained less than 50 multiples and less than 1% of samples showed 100 multiples or above. The low number of multiples present in the sample suggested that even if all multiples are left intact, its potential to influence purity and germination results would be small.

Second, blowing was used to determine if light weight multiples, which contain no caryopsis, can be separated. Regardless of the number of multiples present in the sample, blowing lifted most empty multiples which did not show germination value. On the other hand, most of the multiples that remained in the pure seed portion contained caryopsis larger than ⅓ and the majority of them germinated. This indicated that if a blowing procedure is used, tall fescue florets in the light fraction (including multiples) can be considered inert; whereas those in the heavy portion (including multiples) can be considered pure seed.

Third, the new method (blowing tall fescue first and leaving the multiples intact) was compared with the current AOSA method (where blowing is not required and multiples have to be broken apart). This comparison was performed in-house and followed by a national referee study. The new method produced comparable results to the current AOSA method, furthermore, when the number of multiple florets neared 100 in the blind samples, the new method produced more uniform results. A second year referee demonstrated that breaking or not breaking multiples present in the heavy portion, produced comparable germination results. This indicates that multiples found in the heavy portion (after blowing) has planting like single pure seed units.

The time efficiency was measured during the national referee study. All participant labs saved time using the new method over the current AOSA method. Based on all the above studies, a rule change is proposed. The sample would be blown using the proposed blowing procedure for tall fescue, then, any multiple present in the light portion would be considered inert and multiples present in the heavy portion would be considered pure seed units. In essence, tall fescue would be treated the same as Kentucky bluegrass. The beneficial implications of the new method for testing tall fescue will be discussed.

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Effect of Germination and Fluorescence on Plant Type Produced in Ryegrass

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Some ryegrass samples may achieve maximum germination and express maximum fluorescence or most of the fluorescent trait before the 14 d test period. However, the Cultivar Purity Testing Handbook states "Do not remove non-fluorescent seedlings before 14 days", regardless of whether the sample attains maximum germination potential before the 14 d test period. This study was conducted to explore the possibility and conditions under which the germination and fluorescence tests can be ended before 14 d. There is no published data to quantify or explain the relationship between speed of germination and rate of fluorescence over time. Research has been conducted at the Oregon State University Seed Laboratory to study the relationship between germination, fluorescence and grow out tests, and the effect of pre-chilling treatment on the speed of germination and fluorescence. The first study showed that the germination percentage of 117 out of 142 pre-chilled perennial ryegrass samples did not change from the first count (7 d) to the final count (14 d) or increased by 1%. Similarly, the fluorescence percentage of 132 out of the 142 samples did not increase in the final count compared to the first count (7 d). All tests were conducted within 1–2 months after harvest in 2006.

A national referee study was conducted in 2007 to determine the rate of germination and fluorescence of perennial, annual and intermediate ryegrass samples at 7, 10, 12 and 14 d. Nineteen laboratories from CA, FL, IA, IL, IN, KY, MI, MO, OR, PA, SD, TX, WA, WI, and Canada participated in this referee. Ten seed lots were used in the study representing various varieties from 2006 and 2007 crops. Perennial, annual, and intermediate ryegrass samples that reached maximum germination also expressed near full fluorescence at 7 or 10 d with some exceptions. A study at the OSU seed lab is being conducted to determine whether ending the germination/fluorescence test before 14 d would result in missing some annual ryegrass contaminants. The preliminary results indicated if a sample reached maximum germination and if the variety fluorescence level (VFL) description of a ryegrass cultivar is low (e.g., below

2%) and the number of the fluorescent seedlings in the first count (7 d) is low (i.e., below the VFL), it is unlikely that this sample will have more fluorescent seedlings in the final count to affect the final results. If the VFL and the number of fluorescent seedlings in the first count (7 d) is high, a full 14 d test period would be needed as a safeguard to avoid the potential of missing annual plant contaminants.

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Allelic Discrimination as an Aid in Determining Genetic Purity in Ryegrass

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The seedling root fluorescence (SRF) test has been used to distinguish perennial (*Lolium perenne* L.) and annual (or Italian) (*L. multiflorum*) ryegrass since the 1930s. At times the test has been unreliable and overestimates the amount of annual contamination. The objective of our research for the past several years has been to find and characterize specific genes that may be associated with growth type. We have identified alleles (alternate forms of a gene) of three genes associated with flowering control in grasses. Alleles from two of the genes were effective in predicting growth type. Leaf tissue was harvested from seedlings used in an SRF test and DNA extracted using commercially available purification kits. To cut down on lab costs, only seedlings with SRF, plus five to ten seedlings with non-SRF were analyzed on a real-time PCR machine in Allelic Discrimination (AD) mode. Twenty cultivars were tested in a proof-of-concept panel. Following the SRF test, all seedlings were transplanted to a high intensity growth chamber under continuous light for a grow-out test (GOT) that lasted for 84 d. Plants reached heading throughout the full time of the GOT, but approached a plateau at about 70 d. These results supported that the GOT should be longer than the suggested 42 d in order to be effective. Further, SRF was high in the earliest heading plants and declined in later heading plants, but never fell below 30% of the plants heading in each 7 d increment demonstrating the problems that the SRF test has in predicting contamination. In contrast, however, AD using alleles from the two genes detected growth type differences to about a 3% level, a level equivalent to a 70 d or greater GOT. Detection error rates for the non-SRF plants was less than 0.5% based on presence of two out of three markers that included SRF and alleles of the two genes we used in the study. Allelic Discrimination at the single nucleotide level based on alleles of the *Vrn-1* and *ID1* genes are an effective and rapid method to predict growth type contamination in ryegrass.

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Hormonal Priming with Polyamines: An Effective Approach to Break Dormancy by Enhancing Vigor and Antioxidant System in Tomato (*Lycopersicon esculentum* Mill.) Seeds

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Seed dormancy is a major problem in tomato (*Lycopersicon esculentum* Mill.). Seed priming is known to break seed dormancy. Tomato is among the crops which are responsive to priming. Therefore, the present study evaluates the effects of hormonal priming on germination, seedling vigor and anti-oxidative responses of tomato seeds. Seeds of two tomato cultivars 'Roma' and 'Nagina' were exposed to polyamines (50 mg/L spermine, 50 mg/L spermidine and 50 mg/L putrescine) for 24 h. The results indicated that priming with spermidine and spermine improved seed germination, seedling vigor and enhanced catalase (CAT) and superoxide dismutase (SOD) activities which results in breakdown of dormancy. However, priming with putrescine failed to improve seed vigor which relates to the decreased CAT and SOD activity as well as higher electrical conductivity of seed leachates in tomato seeds. Overall, the response of both tomato cultivars to priming was found similar. It is evident from these results that hormonal priming with spermine and spermidine is very effective tool to break primary dormancy in tomato and to enhance the germination and seedling vigor due to better antioxidant defense system and membrane integrity.

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American Seed Technology Using Distance Education

M. B. McDonald

Today's American seed industry is global in stature. Seeds are increasingly produced in other countries based on advantages in personnel costs, counter-season production locations in the southern hemisphere, geographic location, and ability to produce a diversity of seed crops ranging from recalcitrant to orthodox seeds. Because of these necessary and increasingly complex international approaches to successful global competition, the seed industry requires students with a broader and deeper knowledge of various methods for high quality seed production. The objective of this research is to provide a new approach to global seed technology education that forges a consortium of five leading international agricultural research institutions with strengths in seed biology: The Ohio State University, USA; University of California Davis, USA;

Lincoln University, USA; Escola Superior Agricultura "Luiz de Queiroz," Brazil; and Pontificia Universidad Catolica de Chile. This consortium provides higher quality education in seed biology by drawing on the expertise of more faculty with a diverse knowledge of approaches to successful seed production in differing countries. Results of the consortium allow the use of advances in distance education technology that permit the teaching of courses and offering workshops using internet videoconferencing technology at any location in the world. Two courses (International Seed Production, International Seed Physiology) have been offered using this technology. The courses are listed on the web at http://seedbiology.osu.edu, click courses and HCS 630 and 631. Students can use the text, PowerPoint presentations, and podcasts as preview and review of online interactive videoconferencing classes. Each institution lists the courses as their own courses with visiting faculty providing lectures. In this way, they are able to obtain local student credit hours. Other results of the consortium include the collaborative development of DVDs for coffee, tropical forage grass, maize, and sunflower seed production. Each institution is viewed as a node in the consortium with an ultimate objective to provide a node in each country in the world thus expanding expertise in seed biology. The provision of students with greater international perspectives of the global seed industry and the continuing development of educational seed production resources will build a more globally competitive American seed industry.

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A New Educational Resource: Seed Testing DVD

M. B. McDonald

Seed testing is a complex task requiring many diverse skills. Because of this complexity, one of the important aspects of professional meetings is to convene workshops to enhance analyst standardization. Other approaches to improve standardization are continuing education and publication of detailed handbooks such as the *Seed Technologist Training Manual*. But, these approaches require the seed analyst to travel to the site of learning which requires time and cost. The development of DVDs highlighting various aspects of seed testing is a superior approach to education of seed analysts. Such a DVD has been developed and contains the following modules: The importance of seed testing, seed identification, seed sampling, physical purity testing, germination testing, seed testing tolerances, vigor testing, seed health testing, seed moisture testing, and genetic purity testing. Because the Rules are dynamic and changing yearly, this DVD will necessarily require periodic updating, but the digital format easily permits these changes simply by cutting and pasting. The principal advantage of this DVD is that it allows the professional seed technologist to prepare for certification examinations and permits those in the industry to remain current in latest technological developments. This approach also

has benefits for non-traditional students and students at community colleges and agricultural technical schools that prepare students for four-year programs. Finally, such an approach allows the student the opportunity to learn at their own pace on a computer - an ideal and preferred approach counter to contemporary classroom settings. Portions of this DVD will be demonstrated.

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Analysis of Seed Treatment Loading Rates

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Advances in seed treatment application and formulation technology have resulted in more precise dosing based upon "per seed" loading rates. This has led to treatment loading analysis becoming an integrated component of quality assurance programs. Analysis of seed treatment loading rates has traditionally been done using chromatography following extraction of the treatment from the seed. Now, a Fourier Transform Near Infrared (FT-NIR) method has been developed for non-destructive analysis of the active ingredients (ai) on the seed. In 2006 and 2007, studies have been conducted to measure sample loading variability and assess the suitability of new analytical technologies for determining chemical loading analysis. There are several sources of variability: among samples, treating machinery and analytical method. Within a seed lot, seed weight from sample to sample could vary between from 0.7 to 2.5% for corn (*Zea mays* L.), 1.2 to 3.5% for soybean (*Glycine max* Merrill), and 0.8 to 2.9% for cotton (*Gossypium* spp.), depending upon sample size. Across 10 samples from a single batch of treated seed, loading results could vary as much as 9%. Comparisons of results from different testing methodologies for the same sample showed standard deviations of ~2% for High Performance Liquid Chromatography to ~6% for FT-NIR. A ring test demonstrated that FT-NIR was an acceptable alternative to other methods of analysis for rapid detection of gross chemical misapplication.

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Developing a Standard Seed Testing Protocol for Eastern Gamagrass [*Tripsacum dactyloides* (L.) L.]

Cindy H. Finneseth[1]* and Robert L. Geneve[2]

Eastern gamagrass (*Tripsacum dactyloides* L.), a native warm-season perennial, is being promoted as a grass for forage, wildlife, and conservation purposes. Widespread use, however, is limited by germination and stand. Poor stands have been attributed to a combination of seed dormancy and low seed quality. Additionally, current "AOSA Rules for Testing Seeds" are limited in assessing seed quality. The objectives of this study were to review the current purity guidelines and develop preliminary recommendations for a standardized germination testing protocol for eastern gamagrass. Seed counts were conducted on 40 seed lots, including 8 cultivars and 10 ecotypes or selections. The average number of seed per gram ranged from 7 to 18 (3195 to 8344 seed per pound, respectively). The current AOSA Rules require analysis of 205 g., which is adequate for many cultivars. However, for large-seeded cultivars and collections the working weight for purity analysis should be increased to 340 g. The seed lot used to investigate germination temperature regimes demonstrated typical performance for eastern gamagrass seed lots, with a germination potential of approximately 67% based on initial TZ viability assessment. Stratification and germination temperature had a significant impact on germination percentage. Stratification between 2 and 8 weeks at 5 °C or 10 °C enhanced germination speed, total germination and reduced dormancy compared to untreated seeds. Alternating temperatures were generally more effective in promoting germination and minimizing dormant seed than constant temperatures. Optimal germination occurred at 15/25, 15/35 or 20/30 °C (16 h/8 h), where germination averaged approximately 64% for seeds stratified at 10 °C for 6 weeks. In contrast, seeds germinated at constant 15 or 20 °C germinated at less than 5 and 12% without and with stratification, respectively. Germination temperature contributes to inconsistent seed germination; therefore, it is important that a standardized protocol is developed for this species. Based on preliminary testing, 15/25, 15/35 or 20/30 °C are acceptable temperature regimes for standard germination testing, however, before a Rules change is proposed, testing must be completed using additional seed lots and across laboratories to ensure low variability and repeatability.

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Suggested Tolerances for Tetrazolium Tests

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Regulators use tolerances to test the truthfulness of labeling and for comparing test results within and among laboratories. Tolerances are also used for service tests and for quality control purposes. The tetrazolium (TZ) test is increasingly used as a viability test for many crops because of its advantages, yet the AOSA does not have tolerances for that test. This year (2008), TZ tolerances are proposed to be added to the AOSA Rules by the authors of this paper. Tolerances are the largest non-significant differences between two values. Data of tetrazolium tests are expected to follow the binomial distribution, assuming sampling variation in the absence of experimental error, as do data of germination tests. However, in practice there are sources of experimental errors in each test. Experimental errors have to be identified, quantified and taken into consideration when calculating tolerance values. Possible sources of experimental error in the TZ testing may include but not limited to: improper cutting or piercing technique, variation in seed evaluation due to analyst experience, using different concentrations of TZ solutions, and using different methods and temperatures in moistening or preconditioning the seeds. The principles of calculating the TZ tolerances are established by Miles in his "Handbook of Tolerances" in 1963 and were revised by Michael Kruse who quantified the experimental error factor (f) by calculating the ratio between the observed standard deviation (s) among replications and the expected standard deviation (σ) based on the binomial distribution. Kruse developed tables for comparing two TZ test results of 400 seed each. The authors of this paper computed the tolerances for two tests of 200 seeds each, and for two tests, one 200 seeds and the other 400 seeds. This paper will explain the basis for calculating the experimental error for TZ tests as well as for computing the tolerance values.

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— Posters —

An Index to Quantify the Relationship of Seed Moisture Loss Rate to Seed Desiccation Tolerance in Common Vetch

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Common vetch (*Vicia sativa* L.) seeds are desiccation intolerant when seeds are harvested at immature stages of development and extracted from pods before drying. Drying immature seeds in intact pods may improve desiccation tolerance in association with slow drying rate. Therefore the objective of this experiment was to develop an index to quantify the rate of seed moisture loss of common vetch seeds subjected to four drying methods to their desiccation tolerance. During the reproductive growth stage, seeds were harvested at four development stages: 1) beginning seed fill (BS), 2) full-size seeds (FS), 3) yellow pods (Y), and 4) brown pods (B). Seeds were dried at 20 °C ± 2 by four methods: 1) dried in intact pods, 2) extracted from pods and dried under ambient conditions (Ambient), 3) extracted from pods and rapidly dried over low relative humidity for 6 d (Low RH), 4) extracted from pods and slowly dried over a gradually declining relative humidity for 6 d (Gradually Declining RH). Seed moisture content was measured during the drying period. Seed desiccation tolerance was estimated by measuring the percentage of normal seedlings in standard germination test for air-dried seeds. An index was developed to quantify the drying rate over time. Drying seeds in intact pods improved desiccation tolerance (the percentage normal seedlings in standard germination) as compared with those seeds dried either under ambient, low relative humidity, or gradually declining relative humidity when seeds were harvested at the BS, FS, and Y stages. Slowly drying seeds under a gradually declining relative humidity improved the desiccation tolerance of the seeds harvested at FS stage as compared with those dried under ambient or low relative humidity. Drying seeds in intact pods or over gradually declining relative humidity slowed the drying rate as estimated by seed moisture loss index. As seed moisture loss (SML) index increased, seed desiccation tolerance decreased. A dramatic reduction in seed desiccation tolerance was observed at SML index of 19. These data emphasized that desiccation tolerance is an independent mechanism of seed development which can be acquired in seeds harvested as early as beginning of seed fill.

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Stratification, Hydrogen Peroxide and Germination Temperature Regime Influence Germination and Dormancy Release in Eastern Gamagrass [*Tripsacum dactyloides* (L.) L.]

Cindy H. Finneseth[1*], Robert L. Geneve[2] and Joshua D. Klein[3]

Eastern gamagrass (*Tripsacum dactyloides* L.) is a warm-season perennial grass recommended for forage, wildlife, and conservation purposes. However, its widespread adoption has been limited by poor germination and stand establishment. Less than adequate stands have been attributed to a combination of seed dormancy and low seed quality. The seed lot used for this study demonstrates the typical seed performance for eastern gamagrass with a germination potential of approximately 67% based on pre-treatment TZ viability assessment and lab germination in untreated seeds at approximately 15%. The objective of this study was to investigate whether germination temperature contributes to inconsistent seed germination following dormancy release by stratification or H_2O_2. Stratification between 2 and 8 weeks at 5 °C or 10 °C as well as H_2O_2 application enhanced germination speed, total germination and reduced dormancy compared to untreated seeds. Stratification was more effective than H_2O_2 for dormancy release, but the impact on germination speed was similar. Germination temperature had a significant impact on germination percentage in both stratified and H_2O_2 treated seeds. Alternating temperatures were generally more effective in promoting germination and minimizing dormant seed than constant temperatures. Optimal germination occurred at 15/25, 15/35 or 20/30 °C (16 h/8 h), where germination averaged approximately 64% for seeds stratified at 10°C for 6 weeks and 32% for seeds imbibed in 20% H_2O_2 for 18 h. In contrast, seeds germinated at constant 15 or 20 °C germinated at less than 12 and 15% for stratified and H_2O_2 treated seeds, respectively. These data suggest that germination temperature contributes to poor stands observed for stratified seeds sown under field conditions. Additional work will determine if there is a benefit for combining stratification and H_2O_2 treatments to decrease seed sensitivity to germination temperature and possibly improve stand establishment.

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Red to Far-Red Ratio During Seed Development Affects Lettuce Seed Germinability and Storability

Samuel Contreras[1], Mark A. Bennett[2]*, David Tay[3], James Metzger[2] and Haim Nerson[4]

Lettuce (*Lactuca sativa)* is one of the most important vegetable crops in the world. Thermoinhibition and photodormancy are two characteristics of lettuce seed that frequently reduce germination and seedling emergence in the field. In addition to germinability, storability is an important aspect of lettuce seed quality. The main objective of this study was to evaluate the effects of producing lettuce seeds under light with contrasting red to far-red ratios (R:FR) on seed germinability and storability. 'Tango' lettuce seeds were produced in growth chambers under one of two treatments: i) Red-rich light (R-treatment), and ii) Far-red-rich light (FR-treatment). Seeds produced under the FR-treatment were 5% heavier than seeds from the R-treatment, but in both cases the percentage normal seedlings germinated at 20 °C-light was approximately 100%. When germinated in the dark, seeds from the R-treatment germinated 100% between 12 and 23 °C, and over 50% at 30 °C, while seeds from the FR-treatment germinated less than 35% between 12 and 23 °C and less than 5% at 30 °C. When germinating under light, seeds from the R-treatment had higher germination percentages and rates under a broader range of temperatures, having less thermoinhibition than seeds from the FR-treatment. Seeds from the R-treatment had lower abscisic acid (ABA) content and were better able to germinate when exposed to external ABA concentrations and reduced water potentials than seeds from the FR-treatment. Seed storability as assessed by the accelerated aging test was higher in seeds from the FR-treatment. These results suggest that seed production under environments with higher R:FR light represents a novel approach to the production of lettuce seeds with lower thermoinhibition and photodormancy; however, reduction in seed size and storability are two undesired consequences.

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Temperature During Seed Development Affects Size, Germinability and Storability of Lettuce Seeds

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Seed germinability and storability are important aspects of seed quality determined by the genotype and environment of seed development. Lettuce (*Lactuca sativa*) is one of the most important vegetables in the world. The objective of this study was to determine how temperature of the mother plant environment affects lettuce seed quality. Seeds of cv. Tango were produced in growth chambers under one of two treatments: i) high temperature (HT), with day/night temperatures of 30/20 °C, respectively, and ii) low temperature (LT), with temperatures of 20/10 °C. Seeds produced at LT were 25% heavier than seed from HT, however germination at optimal conditions (20 °C-light) was similar for both treatments. Seeds from HT presented better dark germination at 18, 24 and 29 °C. Germinability (% and rates) under light at temperatures between 20 and 33 °C was similar for seeds from both treatments, however at temperatures between 33 and 40 °C seeds from HT performed better than those from LT. When germinated at negative osmotic potentials, germinability of seed from HT was less affected than LT. After accelerated aging (41 °C, ~100% RH, 72 h) germination of normal seedlings was higher for seeds from HT. Germination after 1, 2 and 3 months of storage at 30 °C and 74% RH was better for seeds from HT. The critical moment for temperature effects was also studied. Seed weight, dark germination at 30 °C and germination at low osmotic potential were shown to be determined earlier during seed development (before 5 and 4 d after flowering for seeds from LT and HT, respectively). On the other hand, seed storability was determined at the end of seed development, after physiological maturity (~15 and 10 d after flowering for LT and HT seeds, respectively). In conclusion, for the lettuce cv Tango, higher seed germinability and storability were attained when seeds were produced at higher temperatures.

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Comparison of Two Paper Towel Media Methods on *Triticum aestivum* Germination Results

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The objective of this study was to evaluate two paper towel methods; horizontal unrolled towels versus vertical positioned rolled towels, as germination test methods for *Triticum aestivum* (wheat). Twenty commercial seed lots of *Triticum aestivum* were evaluated. The methods, substrata type, temperature and duration of the germination tests were identical. Four sheets of 38#, 12" × 24" paper toweling were utilized for the vertically positioned rolled towel method and two, 76#, 16" × 24" paper towels were used for the horizontal unrolled towel method. Germinations were conducted at 20 °C and evaluations were performed at 7 d. The rolled paper towel (T) method had 100 seeds placed on a pre-moistened flat towel. After planting, the towel was folded over, rolled up and placed vertically in a container. This planting process was repeated four times for each sample. The horizontal paper towel method utilized two 76# towels flat on a tray. Water was applied to the tray and paper towel as tray was conveyed under a spraying device. Four 100 seed replicates were planted on the tray while the towel remained horizontal and unrolled. After planting, the trays were inserted into a food service type germination cart and incubated at 20 °C. No significant differences in standard germination percentages were observed between the two methods. However, the horizontal paper towel method eliminated three planting and evaluation steps (watering, rolling up and unrolling to evaluate) thus producing a more streamlined and lower labor cost method.

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Book Review

Seed Purity and Taxonomy: Application of Purity Testing Techniques to Specific Taxonomical Groups of Seeds

Doris Baxter and Lawrence O. Copeland.
Michigan State University Press, East Lansing, Michigan 48823-5245. 2008.
Hardcover, 719 pp., $240.00. ISBN: 978-0-87013-822-5.

This book contains authoritative information on the identification, taxonomy, and purity testing issues for specific families of seeds commonly tested in seed laboratories. While it is not a replacement of the old seed testing reference *Testing Agricultural and Vegetable Seeds* (USDA Handbook 30, 1952), it borrows extensively from this and other past publications that are no longer in print. The book includes over 2,500 seed images taken mainly from Handbook 30 but from other sources as well. Many images and keys from *Identification of Crop and Weed Seeds* (USDA Handbook 219, 1963) and *Manual of the Grasses of the United States* (Hitchcock, 1950) have been included.

The book is arranged into 17 chapters, a comprehensive glossary, and an extensive bibliography with over 260 sources referenced. There is no index, but the Table of Contents includes page listings for all families and genera in the book. Chapter One describes seeds from 12 non-grass monocotyledon families; Chapters Two through Seven include members of the grass family arranged by tribe; and Chapters Eight through Seventeen contain descriptions of seeds from 71 dicotyledonous families. Within this structure, the seeds are arranged alphabetically by family, genus, and species. Common names and some synonyms are also listed.

Each family included in the book has been provided a brief description of characteristics for that family, a seed list with accompanying images, and identification pointers. Many of the families have been provided with additional information, including a description of the seed unit for testing, descriptions of the different genera within the family, special preparation of the purity sample, special testing problems, identification keys, and other general information about the family. In addition, many chapters include charts or tables with seed identification characteristics.

Seed Purity and Taxonomy is intended to aid seed laboratory technicians who perform purity testing procedures on seed samples. It is also a useful resource for other seed industry personnel and anyone interested in the identification and/or taxonomy of seeds. The book has an emphasis on taxonomy and identification and not on purity testing procedures themselves. The text is good and readable, but it can be a bit confusing to match the scientific name on the seed list to the correct image because of the way the figures are labeled. Also, the images are arranged alphabetically rather than taxonomically, so that related families with similar morphology are not adjacent to each other, as they were in Handbook 30. A suggestion for future editions of this book would be to label the top or bottom of each page with the appropriate family and/or genus being described on that page, for ease in use. Also, an index arranged alphabetically by genera would be helpful.

In summary, this is a good reference book for analysts and other persons

interested in seeds. It is a nice compilation of valuable information provided by generations of experts in the field of seed testing and seed taxonomy.

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