Seed Science and Technology:
Research and Testing Needs

Preparing an AOSA Rule Change Proposal

Richard C. Payne

ABSTRACT

Proposals involving changes and additions to the Association of Official Seed Analysts *Rules for Testing Seeds* are submitted annually. The rule proposals are voted on by AOSA members and by registered members of the Society of Commercial Seed Technologists (SCST) at their joint annual meeting. Appropriate guidelines for developing proposals are outlined.

Approximately 20 proposals involving changes and additions to the Association of Official Seed Analysts (AOSA) *Rules for Testing Seeds* are submitted annually. The rule proposals are voted on by AOSA members and by registered members of the Society of Commercial Seed Technologists (SCST) at their joint annual meeting. The rule proposals fall into three general categories: some of the proposals contain only minor editorial changes; other proposals consist of revisions or additions to existing rules; still other proposals introduce new testing procedures. Information in this article will outline appropriate guidelines to be followed when developing new seed testing procedures or revising or proposing additions to existing AOSA rules.

Development of a new or revised testing procedure may begin with basic or applied research. Basic research produces new ideas or approaches involving seed biology or physiology. Applied research uses new ideas or approaches as starting points to develop new testing procedures or to revise and improve existing testing procedures. Observations by seed analysts engaged in routine seed testing can also serve as starting points for developing new testing procedures or revising existing testing procedures.

Some proposed testing procedures are developed using relatively few seed samples, and consequently are often not appropriate for evaluating the diverse seed samples routinely tested by analysts. Official testing procedures must be appropriate for testing a wide range of samples of differing quality. A proposed testing procedure, therefore, should undergo a rigorous standardization process prior to being submitted for consideration as an AOSA rule. Successful completion of the standardization process will ensure that the testing procedure provides uniform and accurate results for a wide range of samples.

The process of standardizing a test should involve subjecting seeds of high, medium, and low quality to the proposed testing procedure. Seed samples of different quality should reflect the samples actually tested for certification, labeling, and regulatory purposes. The use of samples of different quality in the standardization process will ensure that the testing procedure is appropriate for the diverse quality of seed often encountered in routine seed testing.

Varieties with different genetic backgrounds should also be included as seed samples in the standardization process. A proposed testing procedure may work well and produce accurate results for one group of varieties, but

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produce less accurate or more variable results for another group of varieties with different genetic backgrounds. For example, certain problems are often encountered during germination testing of sweet corn (*Zea mays* L. subsp. *mays*) varieties containing high sugar genes that are not encountered when testing other sweet corn varieties. A standardized testing procedure must take into account varietal differences.

In addition, seed samples from different production areas, different production years, and different ecotypes should be used in the standardization process. Seed produced in one production area or from one production year may be uniform in size and physical purity, genetically uniform, and free from disease. Seeds from another production area or production year may be more variable in size, physical purity, or genetic purity, and/or have disease issues. Also, seeds from native species collected from different ecotypes may respond differently to germination temperatures. Using seeds from different production areas, production years, and different ecotypes in the standardization process will help ensure that the results of the standardized test are accurate for all seed samples routinely tested.

The final step in standardizing a new or revised testing procedure is to subject the procedure to referee testing. Clear instructions for conducting the proposed test, along with seed samples reflecting different quality levels, varietal diversity, and different production areas and years, should be sent to participating laboratories. Referee test samples for germination testing should contain pure seed only. Requiring participating laboratories to conduct a purity test to obtain pure seed for germination testing can introduce variation due to differences in the pure seed tested by participating laboratories. The variation in germination test results, due to differences in pure seed, will be mistakenly attributed to variation in the germination testing procedure being evaluated. The number of variables being evaluated in the referee test should be kept to a minimum so the source of variability in test results can be easily determined. Finally, the proposed referee test should be reviewed by someone knowledgeable in statistics to ensure that it is in a format that will allow the results to be analyzed statistically.

Successful completion of the referee test will ensure that seed analysts in different laboratories can achieve the same results using the proposed testing procedure. After the referee test results are received and analyzed, however, the laboratory conducting the referee test may conclude that results from different laboratories do not have acceptable uniformity. In such a case, a second referee test with a revised testing procedure that addresses the source of the non-uniformity should be sent to participating laboratories. If the results of the new referee test are sufficiently uniform, the testing procedure is considered standardized and is ready for submission as a proposed AOSA rule according to the prescribed format. Rule change proposals must be sponsored by an AOSA laboratory, AOSA subcommittee, AOSA committee, or SCST registered member. Guidelines for submitting AOSA rule proposals are located on the AOSA Rules Committee webpage (www.aosaseed.com/rules_committee.htm). Rule proposals should be based on sound scientific data and should not be intended to favor one specific segment of the seed industry.

Research and Testing Needs of Reclamation Species

Gil Waibel

ABSTRACT

The reclamation seed industry is new compared to the agronomic seed industry. Reclamation species have unique characteristics not typically shared by agronomic species. Reclamation species may have varying levels of dormancy and are not usually planted for harvest. In contrast, agronomic species must have uniform maturity at the time of harvest, and if the seed planted does not produce that desired uniformity, it could have a reduced value or even be worthless. The rules for testing seeds have been written with species planted for harvest in mind. This article illustrates the differences between agronomic species and reclamation species. It offers suggestions to better address the seed testing and regulatory needs of reclamation species.

INTRODUCTION

Reclamation species include both native and introduced species which can be planted to reclaim land after fires, mining or other disturbances. Some of these species can also be used as habitat for wildlife and forage for cattle. These species are usually not planted for mechanical row type harvest and can have varying degrees of dormancy. They may or may not be planted into prepared seed beds, and may be broadcast-seeded by air or on the ground. There can be tremendous challenges in planting these species on mountain sides and other hard to reach areas.

The Association of Official Seed Analysts (AOSA) *Rules for Testing Seeds*, International Seed Testing Association (ISTA) *International Rules for Seed Testing*, US *Federal Seed Regulations* and Canadian *Methods and Procedures* have been primarily designed to give meaningful test results for row crop (agronomic and vegetable) species. The first sentence of the AOSA rules (AOSA, 2012a) states: "Seed testing has been developed to aid agriculture in avoiding some of the hazards of crop production by furnishing needed information about seeds that are to be used for planting purposes." The last sentence of the first paragraph of the AOSA rules states: "In all cases the ultimate purpose of making the test is to determine the value of the seed for planting." Species planted for a uniform stand and harvest need to germinate and mature at approximately the same time. Most of these species have very short-lived or no dormancy. ISTA (2013) uses the term "fresh seed" to describe dormancy. The dormancy that agronomic species exhibit is more of a "fresh seed" phenomenon, where dormancy is short-lived.

Many reclamation species have deeper, long-lived levels of dormancy. It can take a short time to years for dormancy to subside, allowing the seed to germinate once conditions are right. This is an important survival characteristic

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for these types of species. If there was no dormancy, and all of the seeds planted germinated all at once, a frost or drought could wipe out the entire generation. If some of the seeds are dormant, the planting will have multiple opportunities to establish over time. On the other hand, a gardener or greenhouse grower may not be happy if there is too much dormancy in a lot of flower seeds they are planting. Ultimately, seed dormancy can be either a good or a bad characteristic, depending on the particular purpose of a planting.

This article will focus on research needs for reclamation species. Suggestions are offered on how the rules for testing seeds can be changed to address the particular requirements of such species. The issue of seed dormancy needs continued study. There are many reclamation species that exhibit dormancy, and these species have differing dormancy mechanisms. A better understanding of dormancy mechanisms will help in the development of meaningful testing protocols, as well as new methods of treating, handling and storing reclamation species. Breaking dormancy in germination tests is currently the way we test species with dormancy. For the most part, we report all seeds that germinate as part of the germination percentage. Reporting dormant seeds as part of the germination percentage can be significantly misleading to the person planting the seed. In contrast, if we had the option to drop the dormancy breaking techniques in the germination test, and determine if the ungerminated seeds at the end of the test are dead or dormant, a more accurate measure of the seed lot quality would be reported.

Providing new testing methodologies for seedsmen to measure and handle the quantity and intensity of dormancy in a seed lot may provide meaningful information for selecting seed lots for various planting projects. Finding better ways to characterize seed lots with dormancy could lead to managing the levels of dormancy in the seed lot, or even inducing or breaking of dormancy in ways that will enhance the seed lot's value.

RESEARCH AND TESTING NEEDS FOR RECLAMATION SPECIES

State and federal 'truth-in-labeling' seed laws and regulations were primarily developed for regulating species planted for harvest. Most of these species do not have dormancy, and if they do, the dormancy is usually short-lived. Reclamation species are normally not planted to be harvested, and often exhibit high levels of dormancy that can last for long periods of time after the seed lot has been planted. More clarity needs to be written into seed control laws and regulations regarding meaningful enforcement of reclamation species. While germination, hard seeds, dormancy and total viable percentages are listed on many seed labels, state seed control officials are enforcing the information on the seed label in differing ways. 'Total viable' percentage is defined by the AOSA (2012a) rules as the sum of germination plus hard seed plus dormant percentages. While germination, hard seed and/or dormancy levels in a seed lot can go up or down over time, the total viable percentage tends to be much more stable. Some states do not recognize the concept of a total viable percentage for labeling in their seed laws and regulations. Some states apply tolerances on each component of total viable seeds. Other states apply tolerances on the total viable percentage only. Perhaps there are other indicators of viability that can be used in the future. Research and education on how to properly regulate reclamation species is needed to help solve these problems.

Seed testing tolerances need to be reevaluated. The tolerances in place now were developed over fifty years ago. In regards to tolerances on reclamation species, there have been suggestions over the years that a 'super-chaffy' tolerance category may have merit. Many reclamation species are highly chaffy and have inherent uniformity issues. Wider tolerance ranges may be needed. Also, wider tolerances on highly chaffy seed mixes may need to be developed. Other approaches could also be considered for tolerances on reclamation species. Currently, species are classified as 'chaffy' or 'not chaffy.' Perhaps we should consider the amount of contamination of inert matter and other species when deciding if a seed lot is chaffy or not. For example, if a seed lot is 95% pure seed or higher, the normal tolerance table (AOSA 2012a) would apply for purity; if the purity percentage is between 90 and 95%, the chaffy tolerance table would be used. If the pure seed is under 90%, a super-chaffy table could be used, if one is developed. These numbers are not meant to define where the cut-off points are, but to illustrate a principle. We would be applying tolerances to seed lot quality characteristics, not to various species which may or may not exhibit chaffy characteristics depending on how the seed lot was managed. Research and much discussion would be needed in order to determine valid tolerances and cut-off points between tables. There may be need for additional tolerance tables, such as one for pure-live seed (PLS).

Work needs to be done to keep the AOSA rules relevant to an evolving reclamation seed industry. Hundreds of reclamation species being sold today are not in the AOSA rules. Efforts must be stepped up to develop protocols for such species and it may be a good idea to check the relevancy of protocols for reclamation species already in the rules. Earlier in this paper, the difference between low levels of dormancy in some agronomic species as compared to the deeper dormancy in many reclamation species was discussed. We could consider using the term 'fresh seed' for the light dormancy in some agronomic species, and the term 'dormancy' for the deeper level of dormancy in reclamation species. Differentiating dormancy into two such terms would help address the testing methodologies for species between short- and long-lived dormancy. With this differentiation, testing protocols can be made separately for short- and long-lived types of dormancy.

The AOSA seedling evaluation rules (AOSA, 2012b) have been written with a seed lot's ability to produce a uniform stand in mind. There is a general unwritten rule for germination evaluation that a root should be at least ½ the length of the shoot to be considered a normal seedling. When the author of this paper was being trained, he was told that a seedling with a root ⅓ the length of the shoot would probably produce a plant, but it would not uniformly mature with the rest of the field at harvest. Such a plant could be worse than a weed. Reclamation species are almost never harvested, and if the seedling has a reasonable chance of making a plant, at what point is the root too short in relation to the shoot? The answer may be defined by plant family, and possibly by genus in some cases.

Why are we required to break dormancy when testing reclamation species? Dormancy is usually a desirable trait for these species. Having the option to either break or not break dormancy in a germination test would better serve the reclamation industry. We have been breaking dormancy for over a hundred years, and in some cases this information is meaningful. In other cases, the buyers and sellers of reclamation species are interested in the level of dormancy at the time the test was made and do not want the dormancy broken and reported as germination. In either case, the total viable percentage will be close, and uniformity in testing would still exist between these two optional methods of germination.

As we conduct more research and our available information grows, more notes in the germination table would be useful. If there is more than one temperature or alternating temperature régime listed in the rules for a species, there may be different reasons to use each of these temperatures. It has been observed that populations of a species originating from the southern part of the country will germinate better at one temperature régime, and a population of the same species originating in the northern part of country will perform better under another temperature régime. When several options are listed in the germination table, giving more information in that table or the seedling evaluation handbook will help a seed analyst select the proper temperature or media, in order to obtain the maximum germination potential of the seed lot being tested. Other information may also be beneficial to help the seed analyst properly apply the rules to each species tested.

Coating and encrusting technologies have been created to enhance uniformity in seed placement, and also to hold moisture next to the seed longer in order to help the seed successfully germinate. Methodologies to break or induce dormancy in seed lots will increase the value of the seed being sold. Every year, new species are added to the reclamation seed market. Research aimed at finding better methods of harvesting seed in areas difficult to access, and research into improved conditioning methods, is always needed. More knowledge about properly storing expensive seeds of reclamation species is also needed.

There is much that the seed testing industry should do in order to address the unique needs of the reclamation seed industry and those who purchase the seed. This paper outlined some key areas that need work. The industry is still young and its knowledge base is growing very rapidly. The seed testing rules and seed control regulations pertaining to reclamation species need much work in order to catch up to the needs of the industry. The problem with meeting these needs is that they are a moving target. Species used today may not be used tomorrow. The reclamation industry has proven to be more than a passing phase. There are real needs that must be addressed. Species with dormancy planted to reclaim lands not intended for harvest will challenge the seed testing industry for years to come.

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Future Seed Testing Needs for Seed Analysts and Researchers—A Personal View

Steve Jones

ABSTRACT

Future seed testing needs for seed analysts and researchers are outlined by the author, who has over 25 years of experience in seed testing and has been the ISTA (International Seed Testing Association) Rules Chair since 2000. The different requirements for analysts, researchers, standardized testing methods and seed associations from a manager's perspective are provided. Future prospects are discussed and conclusions drawn. A major highlighted concern is the lack of structured training opportunities and funding for seed technologists and analysts. The need to raise the profile of people involved in the whole cycle of breeding, growing, testing and certifying seed and grain is identified as an industry need.

INTRODUCTION

When I was approached to provide this article, I wondered what I would write and whether I was the right person to write the article. I was asked to give my views as an analyst on the following:

1) What do seed analysts need from seed researchers and scientists?
2) What areas in seed testing should seed researchers work to improve?
3) What problems do analysts have that could be resolved through experimentation and research?
4) Are there current standardized test methods that are outdated and need to be replaced or eliminated?
5) Should more standardized test methods be added to the rules, or should we focus on reducing the number of test methods?
6) Are analysts adequately trained to handle non-regular (non-standard) tests or test conditions when they arise?
7) Does current published research improve seed testing in general, or do analysts feel that it is too academic and only slightly related to seed testing?

I am not an accredited analyst, or Registered Seed Technologist (RST), but as someone who has been involved with seed testing laboratories for over 25 years, I hope these views are deemed relevant.

BACKGROUND AND EXPERIENCE

Having already said I am not a seed analyst, what is my background and experience? I worked in the UK for 30 years and now in Canada for 5 years. My

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career has been in government funded laboratories, as a researcher, tree seed tester, sampler, sampler trainer, laboratory auditor, manager, and as part of the ISTA/AOSA (Association of Official Seed Analysts)/Canadian seed testing community. My education was mainly on-the-job, having completed an honours degree by day-release and evening study and then a Ph.D. I moved into agricultural seed testing with a job at the National Institute of Agricultural Botany (NIAB) at Cambridge, UK in 1997 and became the Chief Officer of the Official Seed Testing Station for England & Wales in 2000. I also 'inherited' the ISTA Rules Chair role in 2000 and later served on the ISTA Executive Committee (ECOM) for the UK. In 2008, I moved to work in the Seed Science and Technology Section, Saskatoon, Canada, as Chief of Purity, Germination and Accreditation. In Canada, I have continued my role as ISTA Rules Chair and served on the ISTA ECOM as a representative for Canada for the period 2010–2013, which includes being the ECOM regional representative for North America.

As a manager within seed testing, I see a number of requirements to ensure that seed testing continues to progress and maintain reliable standards that facilitate international trade. These requirements involve seed analysts, seed researchers, the different testing rules that exist, the regional seed analysts associations (e.g., Commercial Seed Analysts Association of Canada, or CSAAC) and the seed trade.

ANALYSTS AND RESEARCHERS

Seed analysts should, of course, be well trained and competent, as well as motivated to learn on the job. They should also be aware that the aims of seed testing are met by a combined effort of samplers, their own work as analysts, managers and researchers. The relationship between seed analysts and seed researchers is very important, as it is one way for seed testing to progress by using advanced technologies and modern methods. Analysts use established methods in their daily work, so they are often the best people to identify gaps in existing methods, to suggest improvements, and to identify methods that lack repeatability.

Researchers should consult with potential end-users of their work if their work is to be applied; indeed, they need to make sure that they are answering relevant questions and that their ideas are not totally impractical. For example, it is not useful to add yet another germination method for a species already in the rules, or to develop a seed health test for a fungus that does not impose an economic problem. Close links between researchers and seed analysts can provide guidance regarding what is useful within seed testing and also help to turn novel research ideas into practical tests that are fit for purpose. Seed researchers also need to be aware that during the development and validation of new methods, the seed material used should include seed lots from the major worldwide production areas. They should also consult the current edition of the applicable rules; they often do not realize that ISTA and AOSA rules change every year.

STANDARDIZED TESTING RULES

In Canada, there is the need to use, or at least understand, three sets of rules: AOSA (AOSA, 2012), ISTA (ISTA, 2013) and the Canadian Methods and Procedures for Testing Seed (M&P), (CFIA, 2013). The existing international seed sampling and testing methods of ISTA and AOSA provide a multilateral standardized approach. Countries worldwide and organizations like IPPC (International Plant Protection Convention) and OECD (Organization for Economic Cooperation and Development) make use of the international rules to apply seed quality standards for international trade, and to prevent the movement of invasive species and diseases. The M&P incorporate elements from both the AOSA and ISTA rules, but are designed specifically to provide the analytical information required to grade a seed lot in accordance with the *Seeds Regulations* in Canada (Government of Canada, 2012).

In my opinion, the continued collaboration between ISTA and AOSA to provide harmonized methods is essential. AOSA is already surveying laboratories with the aim of removing some of the multiple options in the germination methods. This is an initiative I agree with, as allowing too many germination methods for one species could lead to lack of uniformity. If the use of in-house germination methods that are not detailed in the rules is to be allowed, then just having one standard reference method in the rules would help facilitate the validation of in-house methods 'as good as' the standard reference method. However, having only one standard method for a test in the rules would require laboratories, at least initially, to provide the standard reference conditions to allow 'in house' validation. I am not yet sure if in-house methods should be allowed across the whole range of tests in the rules, but I do believe ISTA and AOSA should use the same pure seed definitions and definitions for inert matter. In the future, should we use just one shared set of rules that includes both sampling and testing? To achieve this, should lot sizes and sampling methodologies outlined in the current ISTA rules be applied to North America?

Seed testing associations, like AOSA and ISTA, should continue to maintain and promote seed testing as they currently do; in the future, perhaps collaboratively. A main aim should be to make use of new technology and train analysts and laboratories to help achieve uniformity and harmonization in seed testing. I believe expertise in the government laboratories needs to be sustained to maintain seed quality assurance systems, and to ensure the protection of countries from invasive species through the expertise of seed samplers and analysts.

There is also the need to fully utilize the limited number of researchers active in seed science in order to develop new technologies relevant to seed testing. Perhaps the associations can find better ways to provide financial support to encourage new members from both research and testing laboratories; indeed AOSA and SCST are already trying to do this. Financial support to the associations' technical committees and for specific research projects aimed at rules developments would also be useful as finances become even tighter in government laboratories. For the successful continuance of seed quality assurance systems, the associations need to ensure continued support for robust accreditation systems for analysts and laboratories supported by independent proficiency test (PT) provisions.

The international seed trade (e.g. trade organizations and private companies) and private seed laboratories have a role to play by their continued support of the associations; for example, in allowing their staff to actively participate in the work of the different associations around the world, providing seed lots for research, and sponsoring workshops and other initiatives. The seed trade could consider more direct funding of research projects associated with traditional seed testing and provide financial support to training seed analysts. Perhaps the industry could fund university programs in seed technology and testing. Industry could help raise the profile and compensation/rewards for seed analysts.

PROSPECTS FOR THE FUTURE

I had excellent on-the-job training when I started tree seed testing in the UK, which continued at NIAB with analysts who had over 30 years of experience. In Canada, analysts with over 30 years of experience are currently available to train the next generation, but will they be there in the future? We have all heard about the demographic shift; the declining numbers of new people coming into seed testing, and staying, is a concern. Seed analysts have always been at the lower end of the pay scale and rewards; in addition, people move up and away from routine testing.

The ability to visually recognize, identify and name the seeds of 200 to 400 crop and weed species from memory is a unique skill. I do not have that skill, and it takes about 3 years of on-the-job training to acquire such a skill in an established laboratory. Development of computer aids for purity and seed identification, like Lucid keys and image libraries, is already helping analysts do their job more effectively; future innovations could further advance this. It is not only the purity analysts that need to develop their skills. Samplers need to follow standardized methods to provide representative samples. Germination analysts are required to decide which seedlings are normal and which are abnormal. Then there are the other tests for diseases, viability, vigor, moisture and other attributes that all need to be mastered. Seed analysis is an acquired practical skill in addition to the educational background people have; the seed analyst will not disappear in my lifetime or the next 35 years. If I could have one wish granted, it would be to help maintain an interest in seed science and technology. I estimate there are no more than 10,000 seed analysts in the world, so although not the most common occupation, it is essential to the seed industry and current system of seed certification. The numbers of researchers active in seed science is an even smaller number (note: an exact figure for seed analysts and researchers worldwide is difficult to establish, perhaps that is something that seed associations could facilitate in the future).

A problem for seed researchers is that funding is very closely focused on molecular-based research, which does not often have a clear link to applied work such as seed testing. Research and technological advances may one day make it possible to load a seed sample into a single machine, and flip a switch to obtain complete germination and purity results within minutes. My background in seed physiology and training in seed testing predispose me to want to see and feel the results. However, if future researchers can provide me with valid results that correspond to 'real life,' I will use those, and so will others in the seed industry. But how far off in the future is this? In the meantime, I believe the seed industry will still need people, and the proper training and education is the key to survival for seed testing. I hope others will still want to be a part of this work in the future. The continued use of competent people along with regular PT and accreditation of laboratories will be essential.

A unified seed analyst's examination might be something worthwhile to consider, but how would it be administered uniformly across the world? Would the RST model fit this need?

Governments currently have a clear role in regulating the seed industry. Some governments choose to regulate via alternative service delivery mechanisms, and use the government laboratories to provide conformity verification by monitoring private laboratories and the seed industry. I believe alternative service delivery by the private testing laboratories is essential for the seed industry, but I also believe there is an important role for government laboratories. However, some European countries have closed their government (official) seed testing laboratories. If seed testing in governmental laboratories is abandoned, who will provide the independent audit of abilities in laboratories, PT and enforcement monitoring of seed at the point of sale? This could be an expanded role for the seed testing associations. ISTA already provides a laboratory accreditation and PT service for members, while AOSA and SCST certify/accredit analysts. Perhaps third party independent laboratories could also provide the enforcement testing.

Another question is who will pay for the work of monitoring and training of analysts and laboratories if the government laboratories are no longer involved? Perhaps it is the users who should pay, but how can this money be made available? An industry levy could work but at what level? Should the seed breeders, growers, exporters, seed buyers, bread makers, brewers and other end-users all contribute to maintaining the seed certification system? Would the industry be prepared to pay a small amount today for something it gets for 'free' but that could ensure the industry's future? I would be prepared to pay a few cents more per seed lot, or for bread, or a beer, if I knew it was going to be used to ensure future research and training.

CONCLUSIONS

I certainly do not have all the answers to the questions I posed, but I hope to have given some ideas to help start a debate and encourage others to help provide the answers. My biggest concern is for the future funding of the education, training and long term provision of seed analysts; perhaps this is something that the seed industry needs to become more involved with. A joint initiative with the seed associations, seed trade organizations and governments is one possible way to ensure the continued survival of seed analysts and scientists in a professional career. Another issue is how to raise the profile of all those involved in the whole cycle of breeding, growing, testing and certifying seed and grain. We all know how important seed and seed testing are, but do others?

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