Symposium:

Promoting Professionalism in Seed Analysis

A Day in the Life of a Traditional Analyst

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ABSTRACT

The challenges facing the traditional seed analyst today are highly technical and complex. A better understanding of this profession can be obtained by examining the knowledge and practical skills the analyst must possess. The environment that surrounds the seed analyst, including economics, is an important factor that must be addressed if this profession is to obtain parity with other scientific professions. Examples of the value of the commodity the analysis report represents and the environment surrounding the analyst performing the analyses are reviewed.

INTRODUCTION

The science of seed analysis requires the professional seed analyst to transform visual images into mathematical quantities. An analyst examines samples that often appear to be converted moonscapes or small forests (Figures 1, 2). These specimens may contain various species of seed; damaged seed units; fungal sclerotia; abnormal seedlings; dead and decayed seeds; and other components (Figure 3). The complexity of the analytical processes required to transform an unknown sample into known mathematical quantities is monumental. Some of the visual images that must be transformed into mathematical quantities are pure seed, weed seed, inert matter, normal seedlings, and abnormal seedlings (Figures 4, 5). These complex processes require the analyst to possess a comprehensive knowledge of many scientific disciplines including plant taxonomy, systematics, anatomy, physiology, cellular biology, microbiology, pathology, chemistry, entomology, and nematology (Figures 6, 7). Personal attributes of dexterity, good vision, excellent judgment, patience and deductive reasoning are all factors that are required in professional seed analysis.

If an analyst is to retain his/her clients, the analyst must have the ability to understand and explain laws and regulations relating to the sale of seeds, and be able to apply and interpret hundreds of seed testing protocols generated by four separate organizations recognized throughout the world. The analyst today is required to understand a multitude of subjects ranging from seed botany to selection and calibration of testing equipment, and continue their education in the ever-changing field of seed technology (SCST, 1996). If there was not enough pressure on the seed analyst already, the complex process of analyzing a seed sample is also interrelated to economics. Few people outside the field of seed analysis understand the technical difficulties and economic pressures the seed analyst encounters in a day.

By exploring some of the experiences analysts have encountered and the

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Figure 1. ***Brassica juncea,*** **(L.) Czern., Indian mustard seed surface as shown with Scanning Electron Microscope.**

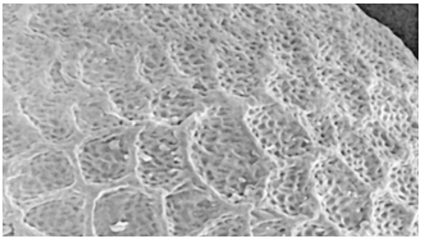
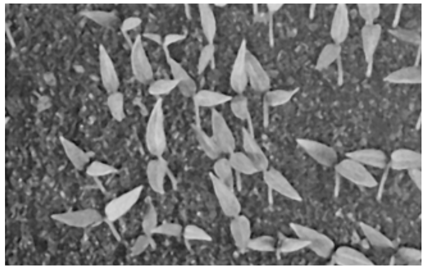


Figure 2. ***Capsicum*** **(L.) spp., pepper seedlings in soil.**



multitude of tests they are required to perform, a better understanding of their world, and the skills and knowledge they must possess can be obtained.

EXPERIENCES

First example

In past wheat sales between China and the Unites States, the sale contract contained a seed quality requirement stating that the seed lots bulked for shipment must be free of darnel ryegrass (*Lolium temulentum* L.). To meet this requirement, a seed analysis report had to be issued by a qualified seed analyst for each seed lot. Some of the bulk shipments contained more than five hundred million pounds of wheat, and could only be loaded in special deepwater ports that were hundreds of miles from the laboratory of the authorized seed analyst. The wheat was sampled by a federal grain inspector at the port and sealed in a container. An independent courier took the sample and traveled by airplane to the authorized seed laboratory. The courier waited at the seed laboratory until the seed analysis report was complete, which usually took about three hours. The courier flew to New York City and hand delivered the seed analysis report to the designated bank holding the funds for the sale. For each day that he bank did not receive the report stating there was no *L. temulentum* in the wheat, the grain company lost more than $8,000 in interest. Thus, the

Figure 5. ***Allium cepa*** **L., onion, normal and abnormal seedlings.**

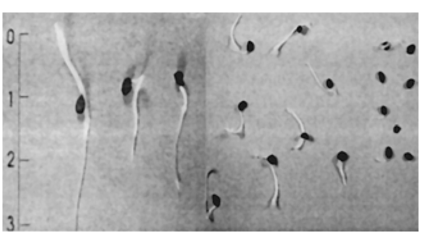


Figure 6. Entomology, insect damage in ***Medicago sativa*** **L., alfalfa, and** ***Vicia sativa*** **L., common vetch must be identified.**

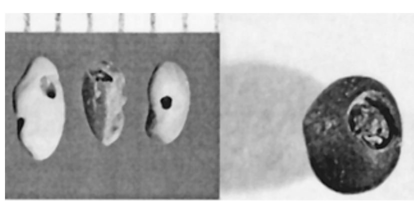


FIGURE 3. Sclerotium.

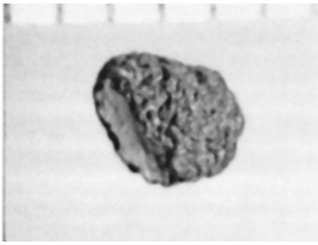


FIGURE 4. Analysis report, mathematical quantities.

Purity Analysis:		Germination Analysis:	
Amount Examined:	10.52 grams		
Pure Seed	99.98 %	Germination . . . . . (normal seedlings)	93 %
Other Crop Seed	0.00 %	Dead Seed	3 %
Inert Matter	0.01 %	Abnormal Seedlings .	4 %
Weed Seed	0.01 %		

grain company, the United States government, and the bank were all demanding a quick analysis and immediate notification, which placed tremendous pressure on the seed analyst.

Beyond the potential for economic loss due to test delays, was the more important question of the quality of the test performed. The analyst knew the first thing that needed to be done was to research the scientific name, to determine if *L. temulentum* could be a synonym of another species or if it could have synonyms. *Lolium temulentum* L., was found to be a valid name, however, there are eight other species of *Lolium* (Hickman, 1993; Mabberley, 1987). The analyst must also determine if the other species of *Lolium* may look like or even be indistinguishable from *L. temulentum.* The analyst must have a working knowledge of plant systematics, morphology, the protocols for testing, and what equipment and techniques to employ during the analysis of the seed sample (Figures 8, 9, 10).

L. temulentum florets often look like florets of *Lolium remotum* Schrank., (Tutin et al., 1980; Musil, 1963), and under certain environmental conditions *Lolium multiflorum* Lam. florets cannot be separated from *L. temulentum* (Figure 11). Many of the wheat samples were heavily contaminated with *Lolium* species and the test to determine if any of the florets or caryopses

FIGURE 7. Nematodes, their presence must be noted.

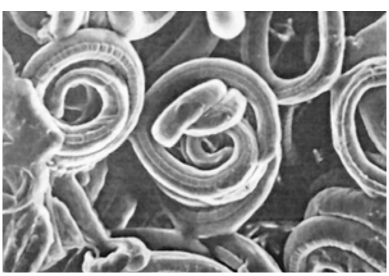


FIGURE 8. Mechanical Purity Station for purity analysis.

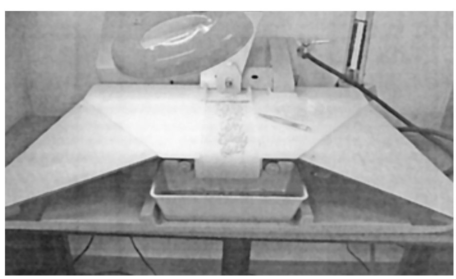


FIGURE 9. Mechanical Purity Station with wheat caryopses being analyzed.

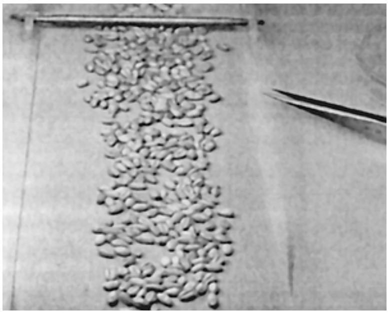
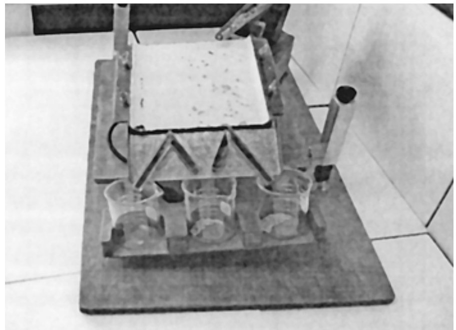


FIGURE 10. Vibrating Incline Deck for seed separation.



could be *L. temulentum* was time consuming. After all examinations some of the florets and caryopses could only be identified as *Lolium* spp. because of their milled condition.

The analyst researched the problem and came to the conclusion that darnel (*L. temulentum*) was undesirable because the entire plant can become toxic (Fuller and McClintock, 1986), and it has a long history as being a poisonous plant. Darnel was highly publicized in earlier times as being poisonous, and reference to this was mentioned in the Bible (Kingsbury, 1964). In rare occurrences humans eating bread made with wheat contaminated with darnel have experienced vertigo or dizziness, abdominal pains, and convulsions followed by death (Everist, 1974). Many species of *Lolium* become toxic, including darnel, as a result of a fungal infection in the plant. The toxin produced by the fungal infection in the plant is transmitted into the caryopses (Fuller and McClintock, 1986). The analyst would have had no problem if the wheat samples had not contained *Lolium* species; however, the samples did contain a large number of *Lolium* florets and caryopses. With this knowledge the role of the analyst quickly became that of an educator in an effort to convince the federal government, the bank, and the grain company that all *Lolium* species should be considered undesirable. The importance of the seed analyst's education and knowledge cannot be over emphasized. The wheat analyses reports representing this one shipment were estimated to represent a sale of over $14,000,000.

Second example

A large percentage of the head lettuce (*Lactuca sativa* L.) sold in November and December in the United Stated is grown in the Imperial Valley of California (Birdsall, 2000). This area is a true desert with a very long and desirable growing season. At lettuce planting time, the daytime temperature is usually between 100 and 115 °F with soil temperatures around 150 °F. Lettuce is normally a cool climate crop, and to germinate the seed under high temperature conditions is a real challenge.

The value of the lettuce crop is so large, and the timetable for planting so

FIGURE 11. Similar florets of *Lolium* species.

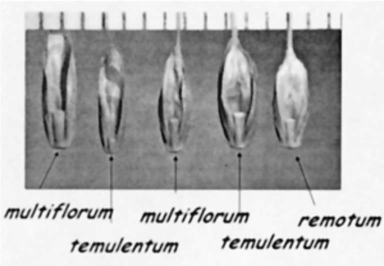
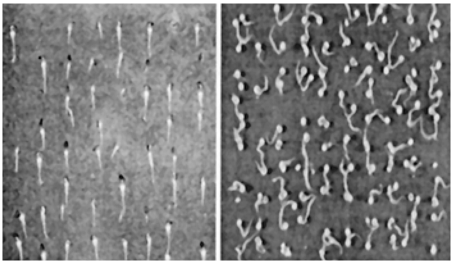


FIGURE 12. *Lactuca sativa* L., lettuce. Germination of raw and pelleted lettuce for 42 hours at 30 °C.



short, that the farmers demand a uniform seedling stand in three days after planting called a "green line." Some companies write contracts with the farmers that stipulate that if the green line is not obtained in three days, the seed company will replant the field at no cost to the farmer.

To deal with the high temperature stress under which the head lettuce seed must germinate in the Imperial Valley, much of the seed planted has been primed, treated with fungicides and growth hormones, and pelleted. Priming the seed promotes more rapid and uniform germination in addition to overcoming high temperature inhibitors (Bradford, 2000). The seed companies request that on both the raw and pelleted seed, a radical emergence test, based on a 24 and 42 hour count when tested at 30 °C, be conducted simultaneously with a standard germination test at 20 °C (AOSA Rules, 1999) (Figure 12). It is crucial to the seed companies that the tests are conducted as close to planting time as possible. Coordinating the completion of the laboratory tests and the planting date is important, because some of the advantages gained by priming the seed can be lost as primed seeds rapidly deteriorate (Bruggink, et al. 1999).

The professional seed analyst is faced with the challenge of dealing with many new testing variables every year. Every time a seed lot is enhanced, the germination may change, and the analyst is expected to understand and cope with the changes. The seed analyst must understand seed physiology and the effects enhancements will have on the germination of the seed. The time that proper research takes to understand and develop new protocols for testing enhanced seed and the loss of productivity in seed analyses can be enormous. Just determining the correct moisture level to promote germination of pelleted seed can be a real challenge, not to mention the effects genetic modifications and growth hormones will have on seed performance (Figure 13). The analyst position requires research to develop new testing protocols. Likewise, a strong background in seed physiology and the time and resources to conduct research are required of the professional analyst. Many of the seed analysis reports issued represent pelleted lettuce seed lots that are valued from $20,000 to $60,000.

Figure 13. Pelleted lettuce germination test.

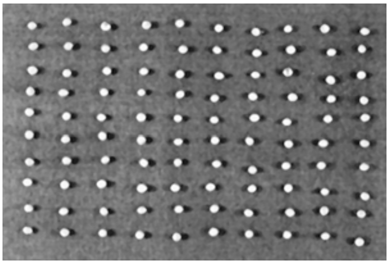
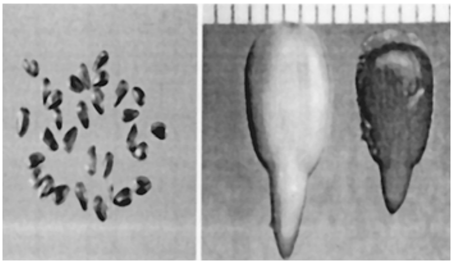


Figure 14. *Helianthus annuus* L., sunflower achenes. Seed from achene showing light staining pattern after tetrazolium test is domant.



There is always the need for timely reporting and the pressure for the seed analysis to be completed sooner. The test method may be changed to speed up the results of the test; however, the speed at which the seed germinates can not usually be changed.

Third example

A seed company in the Southwest United States was selling sunflower seed to farmers in North Dakota based on contracts that required the seed have a high germination percentage. The contracts also required that a seed analysis report be issued confirming that the quality of the seed met or exceeded the quality stated in the contract. The sunflower seed lots were harvested just before they were sent to the seed laboratory for testing. Only very low germination percentages could be obtained from these lots in standard germination tests because of deep seed dormancy. Many methods were employed to try and break the dormancy including the use of dormancy breaking chemicals such as ethephon, potassium nitrate, and gibberellic acid. This situation required a great amount of time and energy by the analyst to search the literature for information on seed dormancy. The dormancy could not be broken in laboratory tests, so a tetrazolium viability test was conducted.

The tetrazolium test indicated the seed was viable but there was some question about the validity of the test because of the light staining patterns on the seed (Peters, 2000) (Figure 14). The analyst tried to convey the information of possible germination problems in the field to the seed company. The seed company wanted the tetrazolium report and nothing else. The analyst had to be very careful in the wording of the report, stating the tetrazolium test indicated dormant seeds with possible high viability. The seed company convinced the farmers to accept the seed based on the tetrazolium viability test and stated that the seed would be transported from the Southwest to North Dakota in refrigerated trucks, which would break the dormancy.

The seed was shipped to North Dakota and planted. One farmer stated that by the end of July he had some plants that were a foot tall, some plants that were two inches tall, and some seeds that had just started to germinate. A lawsuit for over $1,000,000 was filed against the seed company.

Fourth example

One year a large oil-producing nation decided to buy their farmers the best wheat seed money could buy. The contract for the wheat was based on specific quality characteristics of the seed. The transaction was completed with the filing of a seed analysis report stating the seed met the quality standards in the contract. The purchase price for the seed was in excess of $10,000,000. The seed received was not the quality required by contract or stated in the seed analysis report. The oil-producing nation sued the seed laboratory for more than $10,000,000. After investigation into seed testing laboratories, and interviewing seed analysts from other laboratories, the defense attorneys for the seed laboratory were completely bemused.

The attorneys could not understand how a high priced commodity could be bought and sold based on a report that was issued for only twelve dollars. The defense attorneys took the position that the laboratory had a financial gain of only two dollars from the sale of the wheat, therefore the laboratory could not be held responsible for the total amount of the seed sale. The attorneys' disbelief in the disparity between the value of the commodity and the amount charged for the seed analysis report can not be over expressed.

CONCLUSION

The demands placed on professional seed analysts require them to be highly educated and extremely professional. The seed analyst is a scientist with a great deal of knowledge in seed botany, and related subjects that have been acquired through years of education and experience. Millions of dollars in seed sales are transacted with a complete dependency on accurate seed analysis reports. The industry that utilizes these reports to complete their transactions demands that the reports be accurate and contain technical information that is based on scientific research and standardized seed testing protocols developed by seed analysts. These reports are respected and honored throughout the world. A large part of the seed analyst's professional status is tied to the seed analysis report. If this level of professional recognition is to continue, the seed industry and the seed analysts must reach some degree of parity between the value of the commodity and the price of the seed analysis report. The seed industry must share in the expense of developing new seed testing protocols, researching seed testing problems, and the continuing education necessary to maintain the professionalism required of the seed analysts. The time has come for the seed industry and seed analysts to join with each other to form a relationship of respect and parity.

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A Day in the Life of a Genetic Analyst
Education & Experience of the Ideal Genetic Purity Analyst

Diane P. Mesa

ABSTRACT

Changes in seed testing laboratories over the last 10 to 20 years require more from traditional seed analysts. New genetically modified seeds are tested using a variety of chemical, morphological, and genetic assays. Seed technology is becoming a profession with a definite career path, educational preparation, and aptitudes for success. In addition to doing routine seed testing, genetic purity analysts are involved in quality assurance of production processes, customer complaints, lab accreditation, and plant breeding programs. Analysts can enhance their profession both personally by continuing education, for example and in societies or associations by standardizing test methods or certification standards. The SCST is forming a new membership category of Registered Genetic Technologists to recognize genetic purity analysts. New tests, industry consolidation, higher customer expectations, and changes in the work environment all challenge the analyst to evolve professionally.

INTRODUCTION

Changes in the seed industry and our customers require more of seed analysts. There are new genetically modified seeds requiring new tests besides the standard germination and purity tests so familiar to most analysts. Increased customer expectations and awareness of quality further add to the demands placed on traditional seed analysts. Economic and industry changes continue to challenge us to become more professional.

EXPERIENCES AND DISCUSSION

A career in seed genetic purity can be considered to have three job levels. Lab technician is entry level, seed analyst, seed technologist or lab supervisor is the mid-level, and lab manager or QA manager is the top level. Employers include: seed companies, independent testing laboratories, state or federal government, crop improvement associations or private universities. Our professional associations are the Association of Official Seed Analysts (AOSA), Society of Commercial Seed Technologists, (SCST), and the American Society of Agronomy (ASA).

Genetic purity analysts test seeds for genetic or varietal purity using the following: isozyme electrophoresis, peroxidase and hilum checks for soybean varietal characteristics, fluorescence tests, chemical tests (iodine test for corn, phenol test for barley, KOH test for rice, sorghum, NaOH test for wheat), morphology tests, and field grow outs. Tests for special traits include: spray

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tests, media soak tests, feeding tests, antibody tests (ELISA), and tests for contaminants (presence of GMOs). In addition to testing, many analysts handle customer complaints, advise seed producers on quality assurance, and work with plant breeders by testing for PVP characteristics and assisting the inbred line purification process by fingerprinting new lines. New PCR-based tests are being developed for quality assurance purposes that will further challenge seed analysts in future years.

Preparation for specific jobs in genetic purity laboratories depends on the analyst's level of interest. For entry jobs, high school or a two-year agricultural degree is sufficient with training or course work in a life science field. At the mid-level or supervisory level, high school with lab experience should be the minimum with preference for those with a two-year or four-degree in life science or agriculture. Supervisory experience and training is also necessary plus on the job training in seed genetic purity procedures. Being a Registered Seed Technologist (RST) or possessing AOSA certification in seed testing helps distinguish the job candidate. For the advanced or managerial level a four-year degree or graduate degree in life science or agriculture is usually a requirement, RST or AOSA certification, training in seed genetic purity laboratory procedures and managerial experience.

Jobs at the entry level, whether full time or seasonal consist of skill building, routine testing, data entry, sample receiving, media preparation, sample preparation, and clean up chores. The supervisory level typically supervises the technicians, schedules work, trains employees, runs reports, interacts with customers, monitors equipment and supplies, and does the more highly skilled testing. The managerial level is concerned with technical leadership, research projects, managing the laboratory and employees, budgets, cost and expense control, customer complaint issues, process management that monitors quality levels, test validity, accuracy, and reliability; and also feasibility analysis of new tests or methods.

Basic skills, abilities, aptitudes for success at all levels in seed testing include: attention to detail, good eye sight, manual dexterity, computer literacy, intellectual curiosity, enjoyment of routine activities, conscientious and consistent, and of course good communication skills.

Supplemental skills for analysts that will enhance a resume and provide opportunities for advancement and success include: knowledge of seed production, a farm background, or training in plant breeding and molecular biology. It is also beneficial to have exposure to ISO9000, GLP, and other laboratory certification or accreditation, human resources expertise in hiring, training, motivating, terminating, and performance appraisals for laboratory employees. Analysts with business skills in accounting, bookkeeping, cost/benefit, business planning, conflict resolution, time management, safety training in first aid, waste disposal, and chemical hygiene planning will have an advantage. Finally, an analyst may on occasion need mechanical skills in equipment maintenance and repair.

How can seed analysts enhance the profession? We can personally add to our continuing education credits, work toward professional credentials (RST, Registered Genetic Technologist (RGT), AOSA Certification), volunteer for service (team membership, elected office, mentoring, committees), and strive for high personal ethics and integrity on the job. In work groups, societies, or associations, analysts can work toward laboratory accreditation or ISO9000 registration. Societies can improve their public relations, publicity, and use of the Internet for business. Group affiliations are also good for networking and gaining contacts for questions on test procedures and testing difficulties. Only groups working together can come up with standard rules for testing and standardized test procedures.

What does the future hold for genetic purity analysts? There are already new tests being developed for genetic purity using DNA rather than proteins. In the future there could be labeling requirements for tests, and as output traits become more important, analysts will be testing grain or seed for oil, protein, or starch characteristics. Industry changes such as mergers and reorganizations have resulted in seed companies that are either large or small niche players. Independent laboratories have usually specialized by crop or test type. The crop improvement laboratories are a diverse group with no standard type of laboratory and the government laboratories are fewer in number.

Customer expectations have risen resulting in requests for more information, faster service, better repeatability and validity of tests, and advice on what test is needed for a particular variety or production issue. There have been noticeable changes in the seed testing work environment. The testing season is more compressed with seasonal busy times, but year-round work to do. For example a corn purity laboratory is usually busy with testing of the newly harvested crop in the fall, but with winter production in the southern hemisphere, labs have another busy season in early spring. Research and parent seed testing in corn labs can be done in off-season times to spread out the work load. Many labs operate longer hours or run two work shifts during the busy season. The staffs are better educated because of the more "high tech" tests and greater consequences for errors in testing.

Because of the changes in seed testing, there has been a need for a professional designation that expands on the Registered Seed Technologists or Certified AOSA Analysts. The Registered Genetic Technologist has been proposed as a membership category in SCST and will be voted on by the membership in the fall of 2000. Areas of testing expertise for RGTs are bioassay, electrophoresis, ELISA, and PCR. A work group has been formed for exam questions and a study format is being developed.

To conclude, professionalism needs to be cultivated. Genetic seed testing should be given the same status as traditional germination and purity testing. Tests need to be standardized and monitored. Changes in the industry require recognition of seed genetic purity testing.