Seed Technology training in the year 2002

M.B. McDonald[1]; J. Marcos-Filho[2]; W. Jianhua[3]

Abstract

Seed quality will remain the centerpiece of successful agricultural programs in the year 2002 and beyond. As new changes occur in agriculture driven by advancements in biotechnology, seed enhancement technologies, information technology, a more diverse seed user clientele, and communication technologies, successful seed companies will require a knowledgeable and informed workforce to assure high seed quality. A new approach to seed technology training is professed that relies on the establishment of a three-institution consortium composed of Ohio State University (USA), Escola Superior de Agricultural "Luiz Queiroz" (Brazil) and China Agricultural University (China) to achieve this objective. Advantages of the consortium are identified that emphasize the unique strengths of each institution, their geographic advantages representing major climactic/agricultural zones in the world, and differing approaches to applied and basic seed technology training that are facilitated by increasing ease of global communication. This is a superior way to conduct seed technology training that will lead to further agricultural advances in productivity.

Introduction

Seed technology training in the year 2002 – what will it be like?. Will society continue to maintain the present academic structure of educating students in seed biology at universities so they become successful employees of vibrant seed industries?. Will research programs in seed science and technology be sufficiently comprehensive and contemporary so the seed industry is able to rapidly adapt to the demands of a more sophisticated seed consumer?. How will the increasing globalization of international trade of seed be accomplished in view of phytosanitary and other legal requirements?. What is the impact of the WTO on seed training?. Will the continuing increasing adoption and use of modern gene transformed hybrid seed in the rest of the world require a new training curriculum?. Will the value of seed be of more or less importance to the farmer?. Will farmers remain the principal users of seed or will agriculture become more specialized as value-added components are introduced into the seed?

[1] Seed Biology Program, Dept of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210 USA., mcdonald@osu.edu
[2] Depto. de Producao Vegetal-USP/ESALQ, P.O. Box 9, CEP: 13418-900 – Piracicaba, SP, Brasil.
[3] Department of Seed Science and Technology, China Agricultural University, Bejing, China

No one, of course, can answer these questions, but they need to be asked. What is certain is that there is no coordinated effort to determine how the seed industry and its employees will be educated and best serve society in the year 2002. The needs remain the same. Successful agriculture will depend on high quality seeds. Further, while developed countries in North America and Europe have excellent seed industries, the same is not true for the rest of the world. But, seed is now recognized as an international commodity. Most major seed companies have forged alliances with important chemical companies that possess successful biotechnology programs. Examples include Pioneer/DuPont, Monsanto, Novartis, Dow, Syngenta, Mycogen, etc. These international conglomerates will require the successful operation of seed companies to deliver these genetically enhanced products to every part of the world. This means they need a knowledgeable staff capable of producing a quality product and sufficiently competent to solve local problems. Where will these individuals come from and who will be the seed technology decision-makers in the year 2002?

History of Seed Technology training

While many academic institutions have assisted the development of seed technology training, few institutions have had greater impact during the last 30 years than Mississippi State University. This single university brought together a competent academic staff addressing specific seed technology issues, provided outstanding research and teaching facilities, and maintained a long-standing commitment to upgrading the global knowledge about the production of quality seed from the laboratory to the field. The economic impact that this university had worldwide in improving agriculture through the use of quality seed and educating an era of knowledgeable seed technologist is a model to emulate.

As times have changed and individuals retire, the focus of seed technology at Mississippi State has likewise been altered. Gone, and not replaced, is that competent staff. Who now do we turn to for expertise?. Maybe, a thorough knowledge of seed technology is not important. Others might argue that the seed industry can best train those individuals vested in its seed business. Maybe, all that we need to know about high quality seed production is now known. However, the purpose of this discussion is to suggest that none of these solutions are appropriate. Change is rapidly occurring in agriculture and presents new and exciting opportunities. What remains as critical as before, however, is that seed quality will remain the centerpiece of successful agriculture.

What's driving change?

Changes are rapidly occurring in agriculture, many of these at the level of the seed industry. There are at least four factors driving this change that ultimately will culminate in improved and more valuable seed products.

Biotechnology: Without question, biotechnology will have a major impact on the seed industry and seed technology. There presently are three principal foci of biotechnology research. These include: 1) seeds with "input traits" (insect resistance, herbicide resistance, disease resistance, increased yield, etc.). Ultimately, these new products will cause a shift in farmer spending from the agricultural chemical industry where pesticides and chemicals were formerly provided to the emerging seed/agricultural biotechnology industry, 2) seeds with "output traits" (healthier oil content, improved nutritional value, etc.). These products will open new venture opportunities in food and feed markets not available before, and 3) new biotechnology products will eventually extend into pharmaceutical, neutraceutical, and industrial applications (oils, polyesters, etc.). Such products will touch every aspect of a person's normal life.

In addition, the use of DNA and proteomic analyses in seed genetic purity testing, seed lot identification, adventitious presence of GMO seed, etc. are new, revolutionized technologies. Their further development and application in global seed trade will provide the objectiveness in seed testing and identification required in the future. This is also going to provide a much needed tool for plant breeders and plant variety protection agencies to determine the ever increasing number of varieties and to decide whether a newly bred line is a derivative of a new variety.

Who will be the beneficiaries of these products and what does it all mean to seed technology? The beneficiaries include farmers who will obtain higher crop yields from improved insect, weed, and disease control. Because these controls are obtained with less chemical use, less concern will exist about environmental pollution. Farmers will also benefit from lower input costs for pest/weed control and will likely obtain price premiums for seeds with selective output traits. Seed companies such as Pioneer, DuPont, Syngenta/Novartis, etc. will also benefit from increased biotechnology seed premiums that will increase seed margins. Those companies that are the research and development leaders will likely enjoy a market share advantage from being the first to offer their new products. Finally, gene providers such as Monsanto, DuPont, Dow, etc. will obtain additional income from per acre gene fees and, in some cases, increase herbicide market share for companies selling herbicide-resistant seeds.

Is this really going to happen?

Table 1 illustrates that genetically modified corn and soybean seeds are expected to be on five times the acreage for corn and four times the acreage for soybean in the United States by 2001. This will have an impact. It has been estimated that the worldwide 1998 value of seed is $15 billion. By 2005, this value will increase 33% to $20 billion (Furman Selz, 1998). Recognizing the importance of these new markets and genetically modified products, seed technology will necessarily be at the front of ensuring the quality of these new biotechnology enhanced seeds. Moreover, the increasing value of seeds in the future portends that high quality seeds will be paramount to avoid litigation concerning poor performance.

Improved seed enhancement technologies: Our understanding of the factors that govern desiccation tolerance and the activation of seed germination during the earliest stages of imbibition will lead to improved seed enhancement technologies applied to a greater diversity of crop sciences. Most seed companies apply enhancements only to their highest vigor seeds, so new technologies to monitor seed vigor, such as computer imaging may prove valuable. It is also known that enhanced seeds store poorly and proper inventory management will be critical for successful application of enhancements in the future.

Seed as a carrier of added-value agricultural inputs: The seed pelleting and film coating technologies in the past couple of decades have revolutionized the production of many vegetable and ornamental crops. Small, light seeds which are difficult for fast automatic seeding machines to handle in greenhouse plug production are being enlarged. Colors are added on the pellets and in the coats to identify seed and to enhance their appeal in marketing; for example, the golden film coated sunflower seed. Agrochemicals such as insecticides and fungicides have been widely used to place them safely and accurately at the location required by the germinated seed. In legumes, correct rhizobia are incorporated into the pellet to save additional work in seed treatments prior to planting. The experimentation of new biocides in the control of plant pests and diseases and their incorporation in or onto seeds using novel seed treatments and coatings systems will make seed not only a source of good genetic integrity, but also a carrier of added-value agricultural inputs. The incorporation of plant growth substances is under experimentation at OSU.

Information technology in seed business: The globalization of seed production and trade requires more and better communication around the world. Seed companies and organizations have used the information technology (IT) advancement in communication and mass media very effectively. The new advancement in seed technology to take advantage of the IT is still to come. One of the recent developments is the use of color-coded micro magnetic particles to barcode and identify every seed lot. This is an important example of such upcoming innovations.

Farmers aren't the only users of seed: While farmers will continue to be the prime beneficiary of seed improvements, there will be an increasing demand for better quality seeds from vegetable and flower transplant growers. Transplants assure rapid growth and uniform spacing of the crop in the field or greenhouse and the increasing reliance on transplants has spurred the establishment of a new bedding plant industry that germinates seeds in plug flats. These are subsequently marketed for transplant to bedding plant and greenhouse industries. Plug production, however, has created important requirements for high quality seeds that include: 1) each seed placed in a plug cell must germinate. To do otherwise results in unfilled plugs, inefficient use of greenhouse space and the need to refill empty cells – a costly, time consuming operation, 2) all seeds planted in a plug tray must germinate rapidly and uniformly. Rapid emergence is essential for faster greenhouse turnaround and frees up more greenhouse space for additional plants. Uniform emergence permits more accurate timing of shipments and creates a more desirable tray appearance to the buyer. Today's vegetable and flower marketplace demands 100% filled cells in a plug tray and plug growers are willing to pay increased seed costs associated with higher seed quality. The use of synthetic seed has not been realized to date and the increasing interest and research in seed physiology and biochemistry and modern robotic technology may make this technology a future reality.

The globe is smaller: Too often, programs are constrained by state and national boundaries. Recent seed industry merges reveal that these artificial walls will no longer be acceptable in an increasingly dependent global market economy. What will reduce the size of the globe even more dramatically is the rapidly evolving communication revolution. This begins with the decreased costs and ease associated with global travel. Individuals can now travel to differing countries and have meaningful interchanges previously considered difficult to accomplish. But, more important is the ability to exchange concepts and discourse anywhere in the world at a moment's notice by electronic mail instead of “snail” mail that previously required days or weeks. Visiting World Wide Web sites also provides easily accessible data bases formerly requiring weeks/months to assemble. Untapped yet is the vast resource of long-distance learning where classrooms will be conducted anywhere in the world for the benefit of future students. These changes have reduced the distance needed for immediate communication and exchange of ideas, facilitating better learning and research.

A new way to conduct seed technology training: a consortium

The case has been made that seed quality will continue to be an important agricultural concern. The seed industry and users of seed, therefore, must assure that active research programs exist around the world and that there is a steady provision of trained and educated seed technologists to monitor seed quality. Historically, international funding agencies concerned about agricultural development, such as USAID, FAO and the World Bank, have relied on the comprehensive seed technology expertise of one institution as illustrated by the Mississippi State University example. We now argue that this historical process is limiting and that recent developments in communication present a new way to conduct seed technology training. As an example, three institutions (The Ohio State University – OSU, Escola Superior Agricultura “Luiz de Queiroz – ESALQ,” and China Agricultural University – CAU, the premier agricultural university in China with a Department of Seed Science and Technology with successful histories in seed technology have forged a Consortium for International Training in Seed Technology (CITST) to provide comprehensive training in seed technology. The following represents the strengths of CITST.

Comprehensive/Deep: It is a comprehensive program. Forty eight (48) faculty with interests in seeds are participants. Expertise ranges from seed production, seed pathology, seed processing, seed testing, and seed physiology/ biochemistry to seed policies, biodiversity, and on-farm conservation strategies. Crops covered range from orthodox and recalcitrant to agronomic, vegetable, flower, turf, woody/herbaceous, tropical forages and weeds. It is a deep program. CITST partners consider every aspect of seed production ranging from important issues such as seed conservation, use of agro-biodiversity, seed technology, variety testing, seedling establishment, seed legislation to seed policies and management.

Geographic location: Each academic institution was selected because of its geographic location. Ohio State is located in the US corn/soybean belt and has active vegetable and flower seed production. ESALQ is in Brazil where excellent agronomic seed production exists in the south while the north and northeastern regions continue to develop from a seed production perspective. The China Agricultural University affords the opportunity to understand the abundance in genetic diversity of crop genera from south to north. Because of the location of CITST on three continents, anyone interested in seed technology expertise can readily access it. Chosen locations in both the northern and southern hemispheres provide a unique opportunity for multiple-season seed research and evaluation in a year taking advantage of the northern and southern growing seasons.

Developed vs. lesser developed countries: Perhaps one of the greatest constraints facing training in the nuances of seed technology is that this has historically been conducted in developed countries such as the USA or Europe. But, in fact, those places needing training the most in this agricultural discipline are often from developing countries where the importance of high quality seed is only beginning to be understood. The production of seed and the maintenance of seed quality are vastly different processes from these two situations. It makes sense, therefore, to have students in seed technology understand the opportunities and constraints of seed production in both developed and lesser developed countries. The consortium concept espoused here provides that opportunity with China and Brazil being considered lesser developed countries and the USA a developed country.

Facilities: State-of-the-art research and training facilities for seed technology are present at each CITST institution. OSU is noted for its seed physiology and seed production capability. The Ornamental Plant Germplasm Center (OPGC) at the OSU provides a world-class seed processing and testing research facility for horticultural seed. For example, $45,000 (U.S.) singles seed weight sorting machine, a four channel aspirator and thermorgradient germination table are available. ESALQ possesses a model on-site seed processing plant. CAU is a leader in maize, wheat and vegetable crop improvement, new variety protection, GMO testing and seed quality enhancement.ESALQ: pioneer in seed pathology studies in Brazil, consultants to Brazilian seed companies on seed quality control programs.

Seed technology capability: Each CITST institution has experience in education and training of seed technologists. Regular seed technology workshops are offered. Moreover, because CITST partners are affiliated with major land-grant institutions, they draw on a vast array of agricultural expertise to provide unique and in-depth seed technology training. Important issues such as small business development, seed quality control/ISO quality assurance systems, and seed variety legislation in developing countries can be addressed. ESALQ: approximately 150 M.S. theses and Ph.D. dissertations since 1971 (average of 7/year).

International experience: CITST members have recognized international relationships and consider these important components of their training programs. Faculty in the OSU Seed Biology Program have collaborated with or participated in seed development projects in such countries as China, India, Argentina, Brazil, Dominican Republic, Egypt, Sudan, South Africa, Columbia, Mexico, Uganda, Indonesia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Australia, Japan, Korea, Malaysia, Turkey, and Poland. CAU has collaborated with the USA, France, Germany, Poland, Japan, Thailand, India, IRRI and CIMMYT. OSU and ESALQ have had a long-standing academic collaboration since the late 1960s.

Established seed industry/Association relationships: CITST has excellent working relationships with local seed industries. These permit candidate training that represents an integrated continuum from the principles of seed technology learned in the laboratory to the practices of seed production accomplished on the farm or within the company. In addition, it is possible to establish internships with private seed companies where trainees actually participate in seed production on-site. If necessary, it is also possible that specific types of seed technology training can be provided by the seed industry in conjunction with the overall training program. Each CITST member also actively participates in seed associations such as the International Seed Testing Association (ISTA), Association of Official Seed Analysts (AOSA), Union for Plant Variety Protection (UPOV) and others ensuring that competence exists for activities associated with seed testing at the international level.

Advantages of CITST

The Consortium draws on the unique strengths of each institution, their geographic advantages representing major climatic/agricultural zones in the world, and differing approaches to seed technology training. Seed technology training includes short-term Workshops as well as long-term educational training at the Masters/Ph.D. level, when needed. The primary training would be at one institution with secondary training at the other institutions so that students/participants gain additional insights and differing cultural/ technical experiences. Overseas study abroad programs may be adopted and credit points agreed upon between the consortium partners to make the program attractive. Training within seed companies, either short-term or as interns, is encouraged. In-country training by faculty from the three institutions as consultants would be expected.

Through the program, young American students in seed and plant nursery technology and business management will have the opportunity to do research and specific studies in China and Brazil, thereby developing first-hand contacts. These person-to-person contacts are the basis of developing mutual confidence and thus, business cooperation and joint ventures in the future. Similarly, young Chinese and Brazilian seed and plant nursery persons will have the opportunity to be trained at OSU in the USA and will be afforded direct contact with American seed and plant nursery industries. This opportunity allows them to become familiar with American industries and to understand American seed and plant nursery companies. In addition, these exchanges will create the opportunities for the Chinese to gain training and experience in a market-oriented economy in the U.S. and Brazil as well as understand the roles of the public and private sectors in these industries. This will enhance the commercialization of the seed sector in China and create a more conducive environment for overseas seed companies, including those from the USA and Brazil to participate in the Chinese seed and plant nursery business.

The establishment of CITST is a novel approach to global training in seed technology. To continue seed technology training as we have in the past with single institutions ignores the rapid advances in communication as new computer and interactive technologies decrease the size of the world. It also fails to take advantage of the vast expertise of several institutions that differ globally and environmentally. This Symposium and Special Seed Biology Publication represent an illustration of the diversity of seed technology topics and the breadth of expertise that such a Consortium musters. This is a better way to conduct seed technology training in the year 2002.

Reference

Furman Selz, 1998. The Ag Biotech and Seed Industry: The Ag Biotech and Seed Industry: The Biotech Revolution is Here. New York. NY. 744p.

Appendix

Seed Biology Program, Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH USA*

	Faculty
Seed Production	Mark Bennett, vegetables, seedling establishment Jim Beuerlein, agronomic and small grain crops Matt Kleinhenz, vegetables, cultural effects on stand establishment Claudio Pasian, flowers, seed production and enhancements Dan Struve, woody plant seed production David Tay, flower seed production Peter Thomison, corn and soybean seed production
Seed Quality	Mark Bennett, biological and priming seed enhancements Jim Beuerlein, seed enhancement and coatings on agronomic crops Peter Ling, computer imaging to improve seed quality Miller McDonald, development of new seed quality tests Mark Sulc, seed vigor and seedling establishment of forage crops David Tay, flower seed testing, seed processing and pelleting Peter Thomison, cultural and environmental effects on seed quality
Seed Pathology	Steve Nameth, transmission of virus infection into seeds Mac Riedel, control of seedborne fungal and plant pathogens Landon Rhodes, forage legume seed/seedling diseases Peter Thomison, soybean and corn seed diseases
Seed Physiology/ Biochemistry	Mark Bennett, vegetable seed development, maturation and drying Miller McDonald, seed deterioration and early events of imbibition Jim Metzger, flower seed dormancy and germination Dan Struve, woody plant seed dormancy Steve Still, dormancy in herbaceous perennial seeds David Tay, flower seed dormancy, germination and vigor
Seed Genetics/ Molecular Biology	J.C. Jang, sugar sensing in seed development and germination Miller McDonald, electrophoretic techniques to identify varieties
Weed Seed Ecology	John Cardina, modeling of weed seed bank processes Kent Harrison, physiology of summer annual weed seed species Emile Regnier, influence of cultural practices on seed bank species

*Further information on the program can be obtained at www.ag.ohio-state.edu/~seedbio.

Seed Biology Activities, Department of Produção Vegetal (*Crop Science)*, College of Agriculture "Luiz de Queiroz" (ESALQ), University of São Paulo, Brazil*

	Faculty
Seed Production	Silvio Moure Cicero, grain crops Walter Rodrigues da Silva, grain crops Keigo Minami, vegetables
Seed Quality	Julio Marcos-Filho, quality control, seed quality tests Ana D. Coelho Novembre, seed testing Silvio Moure Cicero, computer imaging analysis
Seed Processing	Walter Rodrigues da Silva
Seed Pathology	José O. Machado Menten Maria Heloisa D. Moraes
Seed Physiology	Julio Marcos-Filho, maturation, deterioration, vigor, priming Ana D. Coelho Novembre, water relations
Seed Molecular Biology	Luiz Eduardo A. de Camargo, techniques for cultivar identification, seed deterioration Marcio de C. Silva Filho, DNA Technology Maria Lucia C. Vieira, plant tissue cultures
Weed Seed Ecology	Ricardo Victória-Filho Pedro Jacob Christofoletti
Forestry Seeds	Paulo Y. Kageyama
Plant Propagation	João Alexio Scarpare Filho, fruit crops

*Further information on the program can be obtained at www.esalq.usp.br.

Seed Biology Program, Department of Seed Science and Technology, China Agricultural University, Beijing, China.

Faculty

Crop Improvement and Seed Production

	Dai Jingrui, corn genetics and breeding Sun Baoqi, wheat breeding and seed production Wang Jianhua, corn seed production Zhang Zhengxian, vegetables Chen Ruming, new variety protection
Seed Quality	Xie Caojie, seed quality tests
Seed Processing	Zhao Dule, seed storage Sun Qun
Seed Pathology	Li Jianqiang, seed pathology and coating Liu Xili, seed coating Wang Jianhua, seed treatment
Seed Physiology	Wang Baoming Wang Jianhua, forage seed quality enhancement
Molecular Biology	Xie Caojie, techniques for cultivar identification Wang Guoying, GMO testing Sun Qixin , DNA Technology and plant tissue cultures
Weed Seed	Li Zhaohu

*Further information on the program can be obtained at www.cau.edu.cn

Table 1. Total United States seed industry acreage in genetically modified corn and soybean seeds from 1997 to 2001.

Product	1997	1998	1999	2000	2001
	---------------------MM acres-------------------				
Corn					
Bt	4	12	18	24	30
Roundup ready	3	1	3	5	10
Other herb. resist.	1	4	5	6	6
High oil	0	1	2	3	4
TOTAL	8	18	28	38	50
Soybean					
Roundup ready	8	24	28	31	33
Other herb. resist.	4	5	5	6	6
TOTAL	12	29	33	37	39