AOSA SYMPOSIUM

ENTITLED

SEED AN INTERNTIONAL COMMODITY

INTRODUCTION

SEED AN INTERNATIONAL COMMODITY

J.S. Burris[1]

There is little doubt that we live in a vastly different world today than existed in 1908 when the Association of Official Seed Analysts was formed. Few would argue that we have not witnessed dramatic changes since 1939 when the first Rules for Seed Testing were published. The initial draft fully acknowledged the important contribution that the already decades old International Seed Testing Rules made to the American Rules. Over the last 50+ years the two sets of Rules have been expanded, refined, reviewed and revised to make them as accurate and precise as is reasonably possible. Leading laboratories from all over the globe have contributed time and resources to this selfless task. But as we begin the last decade of the 20th century the combined impetus of the many changes that have occurred during the last five decades and especially the dramatic changes that have occurred in the last 10 years demand that we consider whether enough common ground exists such that the individuals responsible for seed testing world wide could use one common set of reference Rules.

We are part of a global agricultural production system. The interdependence of which was made very clear following the North American drought of 1988. Suddenly many of the world markets for maize seed became potential suppliers to supplement the short supply available in the US. These potential new suppliers represented a whole new set of trade and quality standards to be considered. Fortunately these potential partners were basing their quality standards on a known set of published guides and schemes. Thus the transfer of seed stocks could proceed not impeded by differences in testing protocol or standards. Another important change in the seed industry has been the rapid entry of the multinational corporations. These acquisitions have resulted in immediate affiliations of producers in many countries with the common bond of corporate allegiance to a company located in the U.K., Holland, France, Switzerland, Japan or the US. These multicultural mergers have brought many challenges to seed stock transfer but fortunately not any disagreement on how the quality standards should be measured.

The process initiated during the last decade will accelerate as communications improve and trade restrictions diminish. The seed technologists have a vital role to play in this globalization process. The challenge is for us to promote progress and the orderly transfer of germplasm. To do this may require discussion and compromise. The opportunities are great and the benefits are many not only to agriculture but also ultimately to the consumer. The following papers deal with various aspects of the challenges facing the AOSA and ISTA during their transition to supportive global partners.

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SEED EXPORTS TO THE EUROPEAN ECONOMIC COMMUNITY STATUS OF CERTIFICATION AND SEED ANALYSES

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This discussion will address seed testing and seed certification activity between the United States and the European Economic Community (EEC). However, this will not be an accounting of the quantities of seed that are moving to any given country but will deal with seed movement as it relates to the EEC at large. The EEC is the principal destination for much of the U.S. Certified seed of field crops moving in the international market.

First, let's examine the system under which seed is certified in the EEC and in the United States when intended for international shipment. This seed certification system is based on the Organization for Economic Cooperation and Development (OECD) seed schemes. Schemes are defined here as rules, standards, and procedures. There are 24 member countries in the OECD, the United States, Canada, Australia, and 21 other countries including all the EEC countries. There are 19 nonmember countries that also participate in the OECD seed schemes. Together 43 countries meet annually in Paris to discuss and set policies regarding seed certification standards for the international market place.

There are four sets of OECD schemes for seed certification for movement of seed in international trade in which the United States and the EEC participate. The "Herbage and Oil Seed Schemes" include all the forage and turf grasses and legumes, edible beans and peas, soybeans, sunflower, cotton, sorghum, and the Brassica species; "Cereal Seed Schemes" include wheat, barley, oats, rye, and rice; "Maize Seed Schemes" for corn; and the "Sugar Beet and Fodder Beet Seed Schemes" for the beet species. In addition, there are "Subterranean Clover Seed Schemes" and "Vegetable Seed Schemes" as well, but the United States does not participate in those. The various schemes are published by the OECD in Paris in a booklet and include the rules and regulations for the operation of the OECD seed certification for seeds moving in international trade.

Large quantities of seed move out of the United States under the OECD label. The volume of seed that moved under OECD certification for the last 10 years is shown in Table 1.

In 1977-78 the total volume of seed moving under certification from the United States was 19,473,000 pounds. In 1982-83 the volume grew to 89,157,000 pounds. In 1985-86 and 1986-87 it was 107,942,000, and 128,028,000 pounds, respectively. And, in 1987-88 the volume reached 219,603,000 pounds. As you can clearly see there has been tremendous growth in the OECD seed certification program in the United States.

As can also be seen in Table 1, the seed can be subdivided into "USA varieties" and "Foreign varieties". The foreign varieties are those that have their origin in other countries and have been sent to the United States for increase. In most cases, the increased seed is sent back to the country

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Table 1. The volume of seed that moved under OECD certification for the last 10 years.

Volume of Seed OECD Certified 1966-Present

(thousand pounds)

Year	Total	Foreign Varieties	US Varieties
87-88	219,603	18,139	210,464
86-87	128,028	36,977	91,051
85-86	107,942	20,892	87,050
84-85	77,066	26,246	50,819
83-84	61,119	26,140	34,978
82-83	89,157	31,912	57,245
81-82	73,288	23,112	50,172
80-81	61,368	30,845	30,513
79-80	38,125	26,934	11,190
78-79	24,352	17,682	6,669
77-78	19,473	15,112	4,361

of origin as OECD "Certified" seed. By comparing the US and Foreign variety totals it is clear that most of the growth in seed volume in the past 10 years has been in the USA varieties. The Foreign varieties have shown some increase in volume but have not been consistent. A large portion of the seed produced in the United States for international shipment goes to EEC member countries.

What countries are members of the EEC? The EEC is made up of 12 European member countries. These include Ireland, Britain, Denmark, West Germany, Netherlands, Belgium, Luxembourg, France, Portugal, Spain, Italy, and Greece. Thus, the bulk of western Europe is part of the EEC. In a size comparison the EEC covers an area of 871,000 square miles compared to the 3,716,000 square mile area of the United States.

The rules and regulations that govern the movement to the EEC of seed produced in third countries (countries outside the EEC) are published as two directives in the "Official Journal of the European Communities", Vol. 28, : 195, July 26, 1985. The first directive, 85/355/EEC, "Seventh Council Decision of 27 June 1985 on the equivalence of field inspections carried out in third countries on seed-producing crops" covers requirements for field isolation, inspections, etc. for seed certification in third countries. The second directive, 85/356/EEC, "Seventh Council Decision of 27 June 1985 on the equivalence of seed produced in third countries" covers requirements for seed analysis and quality in third countries. Presently, the third countries recognized by the EEC include the United States, Canada, Austria, Bulgaria, Switzerland, Czechoslovakia, Chile, South Africa, Australia, Cyprus, East Germany, Hungary, Israel, Norway, New Zealand, Poland, Romania, Sweden, Finland, Turkey, and Yugoslavia.

Thus, the EEC has in its two directives standards that they expect seed coming from third countries to meet. The first directive covers field standards, but since the United States and most other third countries, as well as the

EEC, use the OECD schemes, there is seldom a problem with equivalence. The second directive covers seed anslysis and quality. It is here that most difficulties occur for the United States and involve the differences between the AOSA seed testing rules used in the United States and ISTA rules used in the EEC.

The idea of equivalence began in the late 1970's that resulted in the first directives on the subject in June 1980. These directives require that in order to send seed into the EEC, third countries need to follow certain standards thus assuring the seed would be of a given quality. In order to assure this quality the EEC requested from each third country information on their field certification and seed testing procedures. The two EEC equivalence directives published in 1980 were to last for 5 years until June 30, 1985.

The development of the present directive, 85/356/EEC in 1985, had significant impact on the United States. The EEC wanted to require for all third countries the use of ISTA procedures for seed testing and the use of ISTA green and orange certificates. The United States uses AOSA procedures, not ISTA procedures, for its seed testing and the issuance of ISTA green and orange certificates was not possible. Most of the other countries, however, do use ISTA procedures.

In 1985 there was an exchange of letters from the EEC inquiring: How the United States tests its seed? Under what Official authority does seed testing take place? How is it monitored? etc. This exchange laid the ground work for the United States' position today. The following chronicles the events that have occurred since 1985 with a more complete discussion following:

June 30, 1985	Termination of 1980 equivalence Extended for 2 years.
February, 1986	EEC/USDA officials met in Washington, D.C. EEC wanted US to use ISTA procedures and ISTA certificate. Questioned how US maintained control over laboratories. US agreed to develop standard certificate following ISTA format.
February, 1987	US supplied EEC listing of the seed testing laboratories that would be used in OECD certification programs. Stated that AOSA procedures would be used by each. Provided AOSA draft report on "Summary of Differences Between AOSA and ISTA Rules." (1986).
May, 1987	US officials met with EEC "Committee on Seeds" to discuss the "terms of reference for seed testing laboratories and how they are controlled. Committee cannot understand why US does not shift to ISTA procedures.
July, 1987	OECD standard Certificate introduced. EEC Equivalence Extended 1 year.

March/May, 1988	EEC requests information on how samples are drawn, who does it, official monitoring. EEC agrees to the protocol for study of AOSA and ISTA procedures to determine where results may differ significantly.
June, 1988	Met with AOSA Executive Committee to present issues and ask for agreement to cooperate with ISTA in resolving differences.
July, 1988	EEC extends equivalence for 2 years until June 30, 1990.
March, 1989	US/AOSA team met with EEC/ISTA team in Brussels to discuss differences in AOSA and ISTA procedures. Agreed that only a few procedural differences are of critical concern.

Due to the fact that considerable communication was still ongoing when the equivalence terminated June 30, 1985, the EEC decided to extend the equivalence for seven third countries, including the United States, for two additional years, until June 30, 1987. During that time problems were expected to be resolved so that the EEC could be guaranteed complete equivalence in seed quality analysis.

In February 1986, United States and EEC officials met in Washington, DC to discuss the position of the United States relative to meeting the equivalence requirements being put forth by the EEC. The EEC wanted the United States to use ISTA seed testing procedures and issue green and orange certificates. The United States said that was not possible. The EEC also wanted to know how the United States maintained control over the many seed testing laboratories used in our seed testing. The compromise reached at this meeting was that the United States would: 1) introduce a standardized white certificate for all OECD seed lots effective July 1, 1987, with a seed analysis format similar to the ISTA certificate, 2) supply a listing of the seed testing laboratories that would be used in the United States OECD seed certification program (this listing included the State Seed Laboratories, Crop Improvement Laboratories, and some commercial laboratories that were not affiliated with seed companies), and 3) provide a comparison of the magnitude of the differences between the United States AOSA seed testing procedures and the ISTA procedures (this was the 1986 AOSA draft report on "Summary of Differences Between AOSA and ISTA Rules").

In May 1987, United States officials met with the EEC "Committee on Seeds" to discuss the relationship between the United States OECD seed certification authority and the seed testing laboratories. Of interest was the degree of control over and authority given to the seed testing laboratories. Again through this committee the EEC expressed concern that the United States was not preparing to adopt ISTA seed testing procedures. In July 1987, the United States introduced its OECD certificate which included the seed test results in the ISTA format. The EEC extended the United States equivalence for one year to June 30, 1988. In March 1988, the EEC requested additional information on the United States' seed sampling techniques. They wanted to know: 1) How samples are drawn? 2) Who draws the sample? 3) What is the mechanism for "Officially" monitoring the process?

In May 1988, the EEC and the United States reached agreement to work together to closely compare the AOSA and ISTA seed testing rules and to identify the specific areas where differences in seed testing results could be significant. In addition, where these significant differences in testing procedures were found the United States and the EEC agreed to work with the AOSA and the ISTA to encourage adoption of a uniform testing procedure for both organizations.

In June 1988, the United States OECD Designated Authority met with the AOSA Executive Board to present the proposal and to seek agreement to cooperate with ISTA to resolve differences in seed testing procedures. This agreement was obtained. Meanwhile, in July 1988, the EEC, recognizing significant progress in resolving their problem with the United States seed testing procedures, extended the equivalence for the United States for the two remaining years of the normal five-year term, to June 30, 1990.

In March 1989, the U.S. OECD Designated Authority and three AOSA seed testing experts met with the EEC and six ISTA experts to identify the specific points where significant differences between the AOSA and ISTA seed testing procedures would likely be of greatest concern. Agreement was reached on fourteen points where AOSA and ISTA should seek compromise in their procedures to avoid possible differences in results. These fourteen points have been relayed to AOSA and ISTA and both groups are presently considering action to resolve the differences.

What lies down the road? With the progress that has been made in the last few years and the likelihood of continued progress, the EEC is expected to extend equivalence in seeds for the United States well beyond the present termination date of June 30, 1990 (the present date for termination of equivalence for all third countries). In addition, continued compromise is expected between AOSA and ISTA on establishing equivalent seed testing procedures for those seed tests that may provide differing results. When full compromise is reached the EEC should readily acknowledge AOSA seed testing procedures as equivalent to ISTA procedures. When this is accomplished AOSA procedures should be recognized as equivalent to ISTA procedures worldwide.

SEED TESTING: THE INTERNATIONAL PERSPECTIVE

Wilfred Bradnock[1]

INTRODUCTION

The purpose of this paper is to describe why and how seed is tested and documented for the international market. Countries differ in their systems and requirements. Changes are taking place which may, for some countries, extend the kinds of tests required. The international seed market requirements seem complex. However, comparisons with testing and documenting other commodities, such as seed potatoes, or for other purposes, such as plant quarantine, show that international seed testing is comparatively well organized.

When seed is tested for sale within a country there are several parties with different interests in the same test results. For the seed grower the test results may determine whether the seed is marketable and at what price. The results give the seed trader a measure of the relative value of the seed lot compared to other lots. Government officials use test results to decide whether the seed meets legal requirements for sale. For the producer, who buys the seed to grow a crop, the test results provide an assurance that the seed is useful i.e. can be expected to grow a crop acceptably free from other species.

When seed moves internationally the same interested parties use test results for the same purposes. But there are other concerns and complicating factors. Crop seed can be a major vehicle for the transfer of weeds from one country to another — as evidenced by the fact that many of North America's most serious weeds arrived here from Europe in seed. Thus governments may have specific regulations which apply to imported seed and which require testing and documenting to be done in a particular way.

IMPORTING COUNTRY REQUIREMENTS

In 1985 Agriculture Canada undertook a survey of other countries' import requirements. Most countries had regulations specifying standards of purity and germination which had to be met before seed could be released into the country. In some cases there were also specified prohibited weed seeds and standards for other characteristics such as moisture content.

One exception to having import standards, at the time of the survey, was the United Kingdom. Their law only required that seed met the minimum standards when it was marketed. This would obviously allow the processing of seed after arrival. With the change in the EEC structure it is probable that the UK will in the future follow the system in other EEC member countries in requiring seed to meet standards on arrival.

SEED TESTING DOCUMENTATION

In our survey the countries were asked what form of documentation of seed quality would be accepted at the time of import. Of 32 countries replying

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to this question, 28 specified that there should be an International Seed Testing Association certificate. Two countries were prepared to accept either an ISTA certificate or an equivalent government document, one only required a government certificate.

One country indicated that it did not really matter what document accompanied the seed. They would test it on arrival before release and only their test would be considered. Although not found in our survey, we are aware that this is the situation in several countries.

IMPORT CONTROL OBJECTIVES

For seed exporters who have located foreign buyers in other countries, import requirements can prove, at the least, an inconvenience. The importing government's regulations may have the effect of being a non-tariff barrier, even if that is not the stated objective.

The stated objectives of governments in establishing import control regulations fall into two categories:

1. to protect the country from receiving seed of inferior quality, particularly with respect to weed seed content or weed seeds of kinds that are known to be objectionable or that are absent from the importing country.
2. to protect seed buyers from receiving seed of inferior quality.

In evaluating a potential seed market an exporter needs to be aware of the importing countries' regulations and standards. Seed laboratories that undertake tests for export purposes also need to know the other countries' requirements.

IMPORT STANDARDS

There are several ways in which countries specify their import standards. Normally they relate to the way seed sellers are required to inform seed buyers of the quality of seed being sold. The basic choice may be illustrated by the differences in regulatory requirements in the United States and in Canada.

As we Canadians understand it, the U.S. approach is to ensure that the buyer is provided with sufficient information to decide whether seed is acceptable. In this approach seed testing information is displayed in summary form on the label or tag.

The Canadian approach is to set standards below which seed may not be sold and other standards (called grades) representing varying levels of quality. The specific details of the test results are used in determining the grade but do not appear on the label. Other countries follow variants of either the U.S. or Canadian approach. They also vary in their method of considering weed seeds. In some countries weed seeds are limited on a percentage by weight, in others they are limited by number per unit of weight. The weight considered may be the standard quantity used in a purity test. But for noxious weeds there is usually a requirement for testing a larger quantity.

EXPORTING GOVERNMENT INVOLVEMENT

One of the most noteworthy features of our survey of other countries' import requirements was the frequency with which there was a stipulation that the government in the exporting country must provide evidence of seed quality. Laboratories issuing ISTA certificates are all (at present) government laboratories. The option to ISTA certificates was other certificates also from government laboratories.

It appears that importing countries consider that foreign government laboratories will provide independent and objective measurements of seed quality.

ISTA CERTIFICATES

The widespread requirement for ISTA certificates by importing governments, indicated in our survey, does not show the full range of use of these certificates. Apart from government requirements, many seed companies buying seed will specify that the test results must be covered by an ISTA certificate.

The characteristics of ISTA certificates may explain the reason for their popularity. In most cases the ISTA Certificate specified is the Orange International Certificate which is a seedlot certificate. The features of this certificate are as follows:

1. The tests are made on an officially drawn sample by a specified method.
2. The seedlot must be officially identified and sealed.
3. The seedlot must not exceed a specified maximum size.
4. The tests must be made by a specified method.
5. The sampling and testing methods and the lot and sample sizes are all specified in the International Rules of Seed Testing approved by ISTA.
6. When the official analyst signs the certificate, the signature attests to a statement that the sampling, sealing and testing have all been carried out in conformity with the International Rules.

DISCUSSION

A brief examination of the situation with seed potato exports may highlight the advantages of ISTA certificates for seed. There are no international rules for the testing of seed potatoes. In consequence each country sets not only its own standards but also its own test methods. While the standards are normally published, the test methods are often not published.

Thus a seed potato exporter wishing to ship seed potatoes into a country may know the requirements to be met. But the exporter may not know how the importing government will decide whether to permit or refuse entry of the seed potatoes. Inevitably governments in exporting countries become involved in producing documents to try to meet the importing government's requirements. However, in many importing countries there are requirements for both precertification and for further testing on arrival. A significant proportion of shiploads are rejected on arrival making international trade in seed potatoes a very uncertain business.

In contrast the situation with seeds using ISTA certificates is considerably more predictable. The exporter and importer know that the test methods used in the exporting country are standard and should be repeatable in the importing country. In fact many countries consider the results are so reliable that they do not require imported seed to be retested. When they do retest, the results usually agree. If imports are retested, and results do not agree, the laboratories concerned are obligated to try to resolve the difference and determine the true quality of the seed. The motto of the International Seed Testing Association is "Uniformity in Seed Testing".

The ISTA certificate was originally intended as a trading document. Seed sellers used the document as evidence to their buyers of the quality of their seed. The certificates are still used for that purpose in addition to their function in informing governments that seedlots meet import requirements. The certificate is the property of the person paying for the test.

The arrangement for phytosanitary certificates in international trade in plant products is different from that for seed. Under the International Plant Protection Convention (IPPC) governments in exporting countries agree to provide governments in importing countries with certificates attesting to the fact that exported plant products comply with the importing countries' requirements. The phytosanitary certificate is not a trading document as such, it is an official communication between governments.

Although the IPPC may seem a practical way of restricting the movement of pests and diseases, the differences between countries in interpretation can cause restriction in trade in plant products. Unlike ISTA, which operates on a world-wide basis, the countries of IPPC are divided into regional groups, such as the North American Plant Protection Organization (NAPPO) and the European and Mediterranean Plant Protection Organization (EPPO). These groups have in the past operated independently with apparently little obligation of member states in one group to resolve differences with member states in another group. There are no internationally standardized methods for testing for particular pests and diseases. A member state can test by any method it chooses.

These contrasts with seed potato exports and with phytosanitary certification show some advantages in ISTA certification. However, ISTA rules are not the only basis for international trade in seed.

The largest market for Canadian seed and the most important supplier of seed for Canada is the United States. Seed trade between the two countries rarely involves ISTA rules or certificates. For imports into Canada there is recognition not only of federal or state laboratories but also of private laboratories operated by registered seed technologists. The test methods may be those in the AOSA Rules, providing sufficient seed is analysed for purity to determine that the lot meets minimum grade standards.

Of course there are not large differences between AOSA and ISTA rules and these are being reduced. The common principle is that the rules are clearly established on a standardized basis so that successive tests on the same lots in different laboratories should give the same result. Based on years of experience both AOSA and ISTA methods have established a very high level of reliability.

FUTURE DIRECTION

Two thrusts can be identified which indicate that testing for export of seed may be different in the future. These thrusts are: - the increasing concern over the potential movement of diseases with seed and - the increasing trend to accreditation of private laboratories.

Disease Control

Throughout the world there are environmental, health and safety concerns about the use of pesticides. In many countries this has already resulted in the prohibition of the use of some of the most effective seed fungicides, such as the mercurials. It can be anticipated that the pressure to limit the use of pesticides will increase.

At the same time the increasing ease with which large quantities of seed can be moved from continent to continent has heightened awareness of the risk of introducing or spreading diseases with seed. Seed is undoubtedly a most effective means of spreading a disease which may occur on, in or with the seed.

There is in consequence a general trend throughout the world to establish disease standards for seeds. These standards may be used to limit the occurrence of disease already existing in a country. Increasingly they are being used to limit the introduction of infected seed through import controls.

The United States and Canada had some experience with new disease standards in 1988. The EEC introduced new regulations for four diseases of soybeans. These regulations had their major impact on the U.S. and Canada as the main suppliers of the soybean seed used in Europe. All four diseases occur in North America but two of them also occur in Europe.

There were no internationally standardized test methods for any of the diseases and no internationally agreed format for documenting test results. The test methods and system of documentation had to be negotiated on a bilateral basis with individual member states and then agreed to by the E.E.C.

It seems likely that similar requirements, to those for soybeans, may be introduced for diseases of other crops in the future. Obviously, from the point-of-view of the international seed trade such new disease requirements will be perceived as obstruction. However, if such obstructions occur it is necessary to develop ways of ensuring seed can move. Ideally in the future an international organization, preferably ISTA, will set up standardized test methods and certificates for the diseases of concern in international trade.

Accreditation

In the early years of seed testing most laboratories were established by governments or government funded organizations. The testing of seed was perceived as a service activity which governments should perform to enhance crop production by facilitating the measurement of seed quality. Similarly in international seed movement, government laboratories have traditionally functioned in testing both for export and import.

In recent years many governments have been re-examining the role of their laboratories. Canada has followed a trend in other countries in deciding that government laboratories should function for regulatory purposes.

We have been encouraging private laboratories, through training and accreditation, to take over service roles previously carried out by government laboratories. The government, by monitoring the accredited laboratories, can ensure that seed is being properly tested.

Canada has extended this principle to tie in recognition of private laboratories in the United States. We felt able to do this because there is a professional organization (the Society of Commercial Seed Technologists) which grants formal recognition to analysts who have proven their competence (as registered seed technologists). Ideally we would prefer to give recognition to laboratories that are accredited by an organization which assures the capability of both the analyst and the laboratory.

In international seed testing it can be anticipated that the International Seed Testing Association may in the future have to consider granting recognition to private laboratories. It could eventually happen that private laboratories, officially accredited by the government, may one day be authorized by ISTA to issue ISTA certificates.

SUMMARY

Most countries impose standards of purity, germination and weed content which must be met by imported seed.

The Orange International Certificate of the International Seed Testing Association is the most frequently accepted document which importing governments use to release imported seed.

For trade between Canada and the United States the rules of the Association of Official Seed Analysts are the main basis for testing for seed quality.

In the future disease standards may become important for determining the acceptability of imported seed.

The trend to accreditation of private laboratories may eventually be accepted internationally so that private test results are used for international documentation of seed quality.

SEED TESTING: THE FIELD SEED PROSPECTIVE

P. Kim Joo[1]

In recent years, the US seed industry has been globalizing at a very rapid pace. In 1987 the USDA statistics show that the US major field crop seed import and export markets have grown to 6,706 MT and 138,239 MT, respectively. This is a 130% increase in import and a 76% increase in export market compared to that of 1977.

As the international trade is actively growing, the seed produced in one country does not necessarily remain in that country. Seed translocation is predicted to be more active as the border restrictions lift among EEC member countries in western Europe after 1992, when the European community is established. Before the seed can be moved from one country to another, seed producers must meet the seed quality standard which is required by the client. This requirement may be based on the receiving countries' seed law and/or a contract agreed to by the client. Determination of the fulfillment of these requirements is based on the OECD certificate issued by the seed regulatory agency or other accredited organizations using the AOSA and/or the ISTA Seed Testing Rules. Obviously, the AOSA rules are used in North America while ISTA rules apply for the rest of the world.

In North America, the majority of seed is tested by private industry for internal use and/or the official tagging purpose for the domestic market by registered seed technologists, while the international trade outside of North America requires an OECD certificate, which is only issued by official seed certifying agency or seed regulatory testing laboratories. In Western Europe, seed certification which includes the OECD certificate, can be issued by private industry with state authorization in some countries.

Due to the benefit of close working relationships among AOSA and SCST, and the Federal and State seed schools, many US commercial seed technologists have relatively uniform training and interpretation criteria for seed testing techniques. Because seed school training and the certification of seed technologists is not mandatory in all countries utilizing ISTA rules, the interpretation of ISTA rules appear to be widely different. Also, different countries have a different perception of seed testing, which may vary depending on their climatic conditions during the emergence period. These differnt seed testing philosophies also contribute to the variation seen among laboratories using either AOSA or ISTA rules.

With a growing increase in international trade in North America and increasing demands for OECD certificates, the differences in AOSA and ISTA seed testing rules may greatly effect member laboratories. AOSA and ISTA rules differences have been well summarized by Mark Anfinrud on behalf of the AOSA Seedling Evaluation Committee in 1983; by Doug Ashton in 1987, and by the US Technical Team (1989) participating in a discussion meeting organized by the EEC on AOSA and ISTA rules differences (Table 1).

There are a number of areas where the variation in test results are greater between laboratories within an association than between the two associations

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(Tables 2, 3, 4, 5). It is especially important to note that the majority of seed lots are very high quality and do not demonstrate differences among laboratories. However, when differences exist they are caused by lot characteristics (Tables 14, 15, 16). Although there are many variables we are concerned with, our experience with international seed testing is largely with field crops, especially with corn. I will concentrate my discussions on corn germination testing.

As we all know, through years of seed vigor studies, climatic conditions during field emergence can be very different from one location to another and from one year to another in North America. Although world climatic conditions can be described as being much more diverse, for this talk we will divide them into five critical types.

1. Very long wet spring with penetrating cold and low light intensity; UK, Benelux, Northeastern RFG and Scandinavian countries.
2. Prolonged cold and wet spring with crust forming soil; France and Italy.
3. Relatively short cold and wet spring with light sandy loam soil under continental weather; US corn belt, Austria, most Eastern European countries; and the corn belts of China.
4. Mild spring with relatively good emergence conditions; Southern US, Mexico, Argentina, Chile, Turkey and New Zealand.
5. Multicrop regions with a very warm temperature where dry and rainy seasons dictate the planting season; Middle East, Africa, Southeast Asia and some parts of central America.

Due to severe weather conditions and a quality oriented market, the most pronounced differences between ISTA and AOSA germination test results have been observed in regions 1 and 2 above. The split coleoptile issue becomes much more focused, largely due to both soil properties of these regions and the soil preparation practices. Both France and Italy have heavy clay soil with a very high silica content. Most West European countries have small farms and expect very high plant populations which often exceed 80,000 plants per hectar. As a consequence, the farmer watches his field very closely and knows the plant development very well.

Private companies in these countries try to comply with market damands through quality assurance efforts. The primary concerns they have appear to be the poor emergence in crusted soil (Tables 6, 7, 8, 9). If unemerged seed exposed under these conditions are unearthed, generally you will find an abnormal seedling which was unable to break through the crust. Consequently, the split coleoptile becomes a primary concern for laboratory testing. When severe crust formation occurs, it is very common that the seedlot with perfectly normal seedling development may not lift through the crust without mechanical assistance. In the US, split coleoptiles are not as much of a concern since it is a very common practice for the farmer to apply a rotary hoe to break the crust. Private seed companies often offer educational assistance to their customers regarding cultural practices through agronomic services. This results in fewer customer complaints relating to field emergence problems.

Split coleoptiles can be caused by various reasons, but there are two prevailing causes which have been most commonly observed. The first is the genetic one which we used to observe in OH43 and the other is the physical one originated by mechanical abrasion during seed harvest and conditioning. Many single cross hybrids used in the recent decade have had a tendency of sensitivity to mechanical damages. Because of thin pericarp or anatomical structure where the embryo protrudes from the plane of endosperm, there are considerable difficulties in seed production. This has caused a tremendous effort within the industry to minimize physical damage to the seed. With all of the difficult factors affecting seed quality during seed production in the field and conditioning plant, I believe that the seed industry is doing an excellent job in minimizing the mechanical damage.

The major discrepancy in split coleoptile evaluation appears to come from subjective interpretation of AOSA and ISTA rules. While some countries in Europe have a tendency of interpreting a seedling that has a split coleoptile that is ⅓ or more the length of the coleoptile as abnormal, in North America the rules state it may or may not be considered abnormal. Under AOSA rules there is no precise definition of a split coleoptile. Therefore, North American analysts have a tendency of evaluating split coleoptiles as normal unless the true leaves protrude away from the coleoptile. As a result, germination test scores can be substantially different when the lot has genetically weak sutures in the coleoptile or when it has received mechanical impact, which is a very difficult task to avoid in some genotypes unless it is hand harvested and selected.

The interpretation of split coleoptile has expanded in some countries to exceed the ISTA definition. Although ISTA rules indicate that a seedling with ⅓ or more of the coleoptile split is abnormal, analysts in some countries often consider seedlings abnormal with a very small sign of split in any part of the coleoptile. This kind of interpretation seems to be useful as a vigor or trouble shooting test than as an official standard germination test.

Media differences and the tightness of rolling the paper towels can cause artificial distortions of seedlings. These factors may cause an inexperienced seed technologist to have difficulties in accurately evaluating primary split coleoptiles. When the seedling is over 5 days old, most hybrid seedlings have well expanded true leaves so that the mildly split coleoptile is not easy to detect and often this creates a biased evaluation. Results between sand and paper towel germination methods may be different. Seedlings produced in sand and paper towel tests may yield different degrees of split coleoptile, if the technician does not have a keen knowledge of seedling physiology and anatomy. In addition, the duration of the test and presence of light will also cause difficulties in the split coleoptile evaluation.

Seminal root evaluation differences between AOSA and ISTA rules for Graminae can significantly affect germination results. ISTA rules require two seminal roots while AOSA rules require only one. In Graminae, especially in corn, a vigorous normal seedling would have three seminal roots and a primary root at the end of the seventh day of seed testing. Although this is true for many genotypes, there are some genotypes which are genetically slow to elongate seminal roots. When the germination media is not dry, seminal roots or secondary root development is slow for these genotypes.

Also, deteriorating seedlings often lose the ability to produce a primary root, and mechanical damage can either directly cause physical distortion of the root or become the primary cause of deteriorating primary or seminal roots. However, the importance of the primary root or the requirement of the number of seminal roots is not clearly understood. Research evidence is needed to justify which interpretation of seminal roots is valid.

As described in the minutes of the 1983 ISTA Germination Committee and AOSA Seedling Evaluation Committee, the differences in the two sets of rules may have been caused from the description being based on seedlings produced under different conditions (Tables 2, 10). However, as long as differences exist in interpretation of rules among the official laboratories, it is very difficult for a private firm to comply with the rules. Usually the private industry makes a sincere effort to comply with the official laboratory criteria in a given state or country. When there are variations among official laboratories, the ability to have comparable results with the official laboratories becomes extremely difficult (Tables 11, 12, 13).

In conclusion, I would like to propose the following summary:

1. AOSA and ISTA rules differences in germination are not as large in magnitude as we generally perceive, but depending on the lot characteristics, the rules differences can be a very significant cause for variation if it is not applied with caution.
2. Interpretation of two rules with a pre-conceived idea appears to play a very important role in test result discrepancies.
3. Interpretation of rules in individual countries within an organization appears to have greater impact than the differences in the rules themselves.
4. Two organization's (AOSA and ISTA) official laboratories within a country sometimes vary considerably.
5. Perhaps a more precise illustration of seedling evaluation criteria and a continuous training program might be desirable. Maybe it is time to initiate a research project developing an objective seed testing method to avoid subjective interpretations.
6. Field emergence studies and simulated laboratory studies are essential to back up the justification of certain criteria and their function under the given conditions. The field condition should be well defined and the soil moisture content and temperature during the emergence as well as soil property should be defined.
7. More frequent communication and a joint effort between AOSA and ISTA to understand each others criteria appears to be desirable.
8. Exchange of experience between the government and the private industry in ISTA member countries appears to be helpful to eliminate the barrier between the official ISTA laboratories and private industry.

Rules for testing seed define normal seedlings in the standard germination test as germinating under the optimum field conditions. Should the definition of normal or optimum conditions be redefined based on the field conditions in each country or should it be deviated from a standard field condition? Therefore, the rules which apply throughout the world should not be biased by the certain limited climatic conditions but it should maintain the criteria under optimum germination conditions.

While there are a number of good reasons to maintain the identity of two organizations within reasonable limits, the endeavor to minimize the differences in test results should be the goal.

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TABLE 1. DIFFERENCES BETWEEN AOSA AND ISTA RULES IN GERMINATION TESTS

ITEMS OF CONCERN	AOSA	ISTA	COMMENTS/IMPACT
1. **Definition**			No difference
2. **Method**			
Number of seed tested	50 or 100	100	Not significant
Counting seed for germination test	No instruction given	Prescription recommendations	No specific evidence of variation
Germination media	Rules for substrate quality and toxicity included	No specifications for paper towel, sand, filter paper	Could effect evaluation criteria
Water	No specifications	No specifications	Avoid chlorinated water saturated vs. moisture holding capacity is important, could effect some spp.
Temperature	Corn 25^{o}C No specifications on fluctuation	Corn 20, 25, 20-30^{o}C Fluctuation $\pm 1^{o}$C included	Could effect evaluation criteria
Germination apparatus	No specifications	No specifications	No significant source of variation
Use of chemicals	KNO_3 & prechill are primary dormancy breaking method GA, Etheopon and Ethylene are not permitted	GA, Ethepon and Ethylene are permitted	Could effect significantly, but it is different case by case. AOSA and SCST analysts are aware of procedures.
	Disinfection of *Beta vulgaris* is not allowed	Disinfection of *Beta vulgaris* is allowed	Could effect the results

3. **Duration of Test**			Could effect interpretation criteria
4. **Seedling Evaluation**			
Primary root	Not required of certain spp.	Require primary root	Source of significant variance
	*Some spp. secondary root takes over primary roots	*Stubby primary root-abnormal	
Seminal root	One vigorous seminal root	At least 2 seminal roots	Source of significant variance
Split coleoptile	May or may not be abnormal	More than ⅓ coleoptile split is abnormal	source of significant variance
Cotyledon	Half or more cotyledons required	No cotyledon required	Source of significant variance
5. **Reporting Results**			
Retest	Omition of replicate	Retested mandatory	Not enough significance
Report	Dormant seed, ungerminated seed	Fresh seed	Could effect significantly

* Genera effected by this is listed in the 1983 AOSA Seedling Evaluation Committee and ISTA Germination Committee Meeting report.

TABLE 2. STANDARD GERMINATION TEST

LAB	TEMP	LIGHT	FIRST COUNT	MEDIA	COMMENTS
18, 20	20-30	YES	4	PAPER	PAPER SIZE 12" x 36"
28, 32	25	YES	NO	SAND	¾" ABOVE SEED ¾" BELOW SEED
4	20-30	YES	NO	PAPER	SEED NORMALLY TREATED
10	25	NO	4	PAPER	
14	25	YES	NO	SAND	
20, 22, 24	25	YES	NO	SAND	¾" ABOVE SEED ¾" BELOW SEED
26			UNKNOWN		

(TEST DURATION WAS 7)
(# OF SEEDS PER REP WAS 100 EXCEPT FOR 28, 32, 4)

TABLE 3. STANDARD GERMINATION RESULTS OF TREATED SEED FROM AOSA AND ISTA USING 10 LOTS OF SEED

TREATED SEED

	AOSA LABS								ISTA LABS								OVERALL
LOT	4	10	14	18	28	MEAN	STD	VAR	20	22	24	26	32	MEAN	STD	VAR	MEAN
1	95.0	93.0	90.4	91.0	91.0	92.0	1.70	2.9	91.0	91.0	92.0	89.0	74.0	87.4	6.77	45.8	89.7
2	99.0	99.0	99.0	97.0	98.0	70.4	0.80	0.6	97.0	98.0	98.0	97.0	88.0	95.6	3.82	14.6	97.0
3	97.0	97.0	96.8	98.0	87.0	95.1	4.10	16.8	96.0	94.0	97.0	80.0	91.0	91.6	6.15	37.8	93.4
4	94.4	91.0	91.2	90.0	90.0	91.3	1.62	2.6	90.0	89.0	90.0	88.0	69.0	85.2	8.13	66.2	88.3
5	98.0	97.0	96.4	98.0	97.0	97.2	0.63	0.4	98.0	98.0	97.0	96.0	92.0	96.2	2.22	5.0	96.7
6	95.6	94.0	88.8	98.0	90.0	93.2	3.44	11.8	93.0	84.0	92.0	88.0	85.0	88.4	3.61	13.0	90.8
7	96.0	98.0	97.2	97.0	93.0	96.2	1.74	3.0	96.0	96.0	96.0	92.0	91.0	94.2	2.22	5.0	95.2
8	95.0	94.0	92.4	95.0	89.0	93.0	2.25	5.1	93.0	94.0	89.0	88.0	75.0	87.8	6.79	46.2	90.4
9	86.6	87.0	87.2	91.0	81.0	86.6	3.20	10.3	87.0	85.0	86.0	77.0	78.0	82.6	4.22	17.8	84.6
10	97.2	97.0	96.4	99.0	99.0	97.7	1.08	1.2	99.0	92.0	98.0	98.0	90.0	95.4	3.66	13.4	96.6
MEAN	95.4	94.7	93.6	95.4	91.5	94.1	1.47	2.2	94.0	92.1	93.5	89.3	83.3	90.4	3.92	15.4	92.3

TABLE 4. STANDARD GERMINATION RESULTS OF UNTREATED SEED FROM AOSA AND ISTA USING 10 LOTS OF SEED

UNTREATED SEED

	AOSA LABS								ISTA LABS								OVERALL
LOT	4	10	14	18	28	MEAN	STD	VAR	20	22	24	26	32	MEAN	STD	VAR	MEAN
1	90.0	86.0	89.6	88.0	89.0	88.5	1.43	2.0	85.0	89.0	88.0	88.0	83.0	86.6	2.24	5.0	87.6
2	84.0	94.0	99.6	98.0	97.0	94.5	5.57	31.0	98.0	98.0	98.0	97.0	91.0	96.4	2.72	7.4	95.5
3	92.0	96.0	97.6	97.0	91.0	94.7	2.70	7.3	97.0	96.0	96.0	84.0	91.0	92.8	4.87	23.8	93.8
4	70.0	92.0	87.6	90.0	88.0	85.5	7.92	62.7	90.0	92.0	91.0	88.0	78.0	87.8	5.07	25.8	86.7
5	82.0	96.0	95.2	95.0	98.0	93.2	5.72	32.7	94.0	97.0	95.0	97.0	89.0	94.4	2.93	8.6	93.8
6	77.0	90.0	89.2	88.0	85.0	85.8	4.74	22.4	86.0	88.0	90.0	83.0	75.0	84.4	5.23	27.4	85.1
7	82.0	99.0	93.6	97.0	96.0	93.9	6.07	36.9	97.0	96.0	96.0	96.0	89.0	98.4	2.92	8.6	94.4
8	82.0	93.0	92.0	95.0	85.0	89.4	5.00	25.0	94.0	92.0	94.0	84.0	75.0	87.8	7.38	54.6	88.6
9	76.0	87.0	94.0	91.0	86.0	86.8	6.11	37.4	88.0	90.0	86.0	79.0	75.0	83.6	5.67	32.2	85.2
10	82.0	96.0	99.6	99.0	97.0	94.7	6.49	42.2	98.0	98.0	98.0	96.0	94.0	96.8	1.6	2.6	95.8
MEAN	91.7	92.9	94.0	93.8	91.2	90.7	4.62	21.3	92.7	93.6	93.2	89.2	84.0	90.5	3.62	13.1	90.6

TABLE 5. SUMMARY OF TWO LABS WHERE SAMPLES READ USING BOTH AOSA AND ISTA RULES

	UNTREATED						TREATED						OVERALL		
	AOSA			ISTA			AOSA			ISTA			AOSA	ISTA	OVERALL MEAN
LOT	18	28	MEAN	20	26	MEAN	18	28	MEAN	20	26	MEAN			
1	88.0	89.0	88.5	85.0	88.0	86.5	91.1	91.1	91.1	91.1	89.0	90.0	89.8	88.3	89.0
2	98.0	97.0	97.5	98.0	97.0	97.5	97.0	98.0	97.5	97.0	97.0	97.0	97.5	97.8	97.4
3	97.0	91.0	94.0	97.0	84.0	90.5	98.0	87.0	92.5	96.0	80.0	88.0	93.3	89.3	91.3
4	90.0	88.0	89.0	90.0	88.0	89.0	90.0	90.0	90.0	90.0	88.0	89.0	89.5	89.0	89.3
5	95.0	98.0	96.5	94.0	97.0	95.5	98.0	97.0	97.5	98.0	96.0	97.0	97.0	96.3	96.6
6	88.0	85.0	86.5	86.0	83.0	84.5	98.0	90.0	94.0	93.0	88.0	90.5	90.3	87.5	88.9
7	97.0	96.0	96.5	97.0	96.0	96.5	97.0	93.0	95.0	96.0	92.0	94.0	95.8	95.3	95.5
8	95.0	85.0	90.0	94.0	84.0	89.0	95.0	89.0	92.0	93.0	88.0	90.5	91.0	89.8	90.4
9	91.0	86.0	88.5	88.0	79.0	83.5	91.0	81.0	86.0	87.0	77.0	82.0	87.3	82.8	85.0
10	99.0	97.0	98.0	98.0	96.0	97.0	99.0	99.0	99.0	99.0	98.0	98.5	98.5	97.8	98.1
MEAN	93.8	91.2	92.5	92.7	89.2	91.0	95.4	91.5	93.5	94.0	89.3	91.7	93.0	91.3	92.1

TABLE 6. 1988 FIELD EMERGENCE STUDY - AUSTRIA RESULTS

Seed Lot	Laboratory Tests							Field Emergence	
	Austria		Pioneer	French	Dye Test				
	Warm Test	Cold Test	Cold Test	Sand Test	I	II	III	1st Count	Final Count
	%								
1081	98	92	87	91	91	9	0	94	96
1085	94	86	82	90	67	31	2	90	88
1086	93	89	92	91	70	25	5	84	94
1088	98	93	84	98	90	10	0	94	94
1089	96	91	95	96	94	6	0	96	96
1092	94	88	88	91	52	42	6	92	92
1093	98	91	86	87	61	35	4	92	92
1095	92	92	89	89	65	31	4	96	94
1096	96	85	91	90	67	23	4	86	88
1097	96	92	94	92	61	35	4	88	90
1099	97	92	91	94	51	39	10	90	90
1179	95	84	84	90	65	31	4	94	94

Correlation Coefficients	
Austrian Warm Test vs. Final Count	0.06
Austrian Cold Test vs. Final Count	0.39
Pioneer Cold Test vs. Final Count	0.08
French Sand Test vs. Final Count	0.27

TABLE 7. 1988 FIELD EMERGENCE STUDY - FRANCE RESULTS

Seed Lot	Laboratory Tests: Warm Test[1] 5 Days Normal	5 Days M.S.[2]	5 Days S.S[3]	7 Days Normal	Cold Test Normal	Cold Test M.S.	Cold Test S.S.	Field Emergence LaMans[4]	Rabis[5]	Lanne.[6]
	%									
1081	89	0	3	96	85	2	1	95	98	98
1085	88	3	7	98	80	2	6	92	95	95
1086	91	1	4	95	80	2	5	92	96	95
1088	93	1	0	99	90	1	1	97	97	97
1089	98	1	0	99	90	1	1	94	98	98
1092	85	4	7	88	87	1	2	96	94	95
1093	86	4	7	88	88	1	5	93	95	93
1095	92	1	3	95	77	2	7	95	96	96
1096	95	0	4	95	85	1	8	93	94	92
1097	90	2	5	93	89	1	4	91	96	94
1099	91	2	5	92	84	2	7	92	95	96
1179	91	2	4	93	79	2	4	93	97	96

Correlation Coefficients	
5 Day Warm Test vs. LeMans F.E.	0.02
5 Day M.S. vs. LeMans F.E.	-0.12
5 Day S.S. vs. LeMans F.E.	-0.45
7 Day Warm Test vs. LeMans F.E.	0.32
Cold Test vs. LeMans F.E.	0.41
5 Day Warm Test vs. Rabis F.E.	0.43
5 Day M.S. vs. Rabis F.E.	0.15
5 Day S.S. vs. Rabis F.E.	-0.74
7 Day Warm Test vs. Rabis F.E.	0.71
Cold Test vs. Rabis F.E.	0.11
5 Day Warm Test vs. Lannem. F.E.	-0.03
5 Day M.S. vs. Lannemezan F.E.	-0.32
5 Day S.S. vs. Lannemezan F.E.	-0.63
7 Day Warm Test vs. Lannem. F.E.	0.55
Cold Test vs. Lannemezan F.E.	0.03

[1] French warm test planted into sand at 18°C
[2] M.S. = Mild split coleoptile
[3] S.S. = Severe split coleoptile
[4] LeMars locations planted April 25, 1988
[5] Rabis location planted April 28, 1988
[6] Lannemezan location planted June 22, 1988

TABLE 8. 1988 FIELD EMERGENCE STUDY - ITALY RESULTS

Seed Lot	Laboratory Tests: Warm test Normal	Laboratory Tests: Warm test M.S.	Laboratory Tests: Cold Test	Field Emergence (F.E.): Torino[1]	Field Emergence (F.E.): Cremora[1]
	%				
1081	95	4	91	97	97
1085	85	8	83	86	89
1086	91	5	90	94	94
1088	97	1	92	97	98
1089	97	1	96	98	97
1092	92	4	85	92	90
1093	88	6	87	90	91
1095	89	4	88	93	92
1096	93	3	82	93	94
1097	90	5	80	92	92
1099	93	3	89	94	92
1179	88	5	81	91	91

Correlation Coefficients	
Warm Test Normal vs. Torino F.E.	0.94
Warm Test Mild Split vs. Torino F.E.	-0.88
Cold Test vs. Torino F.E.	0.75
Warm Test Normal vs. Cremora F.E.	0.88
Warm Test Mild Split vs. Cremora F.E.	-0.77
Cold Test vs. Cremora F.E.	0.71

[1] Torino Location planted on May 7, 1988 [2] Cremora Location planted on May 5, 1988

TABLE 9. CORRELATION COEFFICIENT BETWEEN LABORATORY TESTS AND FIELD EMERGENCE IN 1986

			Warm Test	Cold Test
France	Angouler	1	0.65	0.79
		2	0.60	0.76
	Aries	1	0.45	0.33
		2	0.44	0.32
Italy	Bordolano	1	0.46	0.38
		2	0.28	0.17
	Malagnino	1	0.39	0.41
		2	0.33	0.28
	Torino	1	0.56	0.49
		2	0.50	0.45
France	Rebais	1	-0.07	0.55
		2	0.04	0.36
	Cucques	1	-0.01	0.72
		2	0.08	0.77

TABLE 10. 1988 WARM GERMINATION TEST PROCEDURES

Country	Temperature	Media	Testing Evaluation	Period
Austria	25°C	Paper Towel 14.5 x 62 cm	ISTA Not strict Generous in abnormals	7 Days
Hungary	25°C	Paper Towel	ISTA Not strict Generous in abnormals	7 Days
Romania	25°C	Paper Towel	ISTA Not strict Generous in abnormals	7 Days
France	18°C	Sand	Severe Evaluation	6 Days
Italy	25°C	Sand	ISTA	6 Days
USA	27°C	Paper Towel 30.5 X 37.5 cm	AOSA	5 Days

TABLE 11. TEST DIFFERENCES BETWEEN LABS (AUSTRIA)

HYBRID	LOT	KERNEL SIZE	GOVERNMENT ISTA WARM TEST	GOVERNMENT ISTA COLD TEST	PIONEER LABORATORY WARM TEST	PIONEER LABORATORY FRENCH SAND TEST	PIONEER LABORATORY ISTA COLD TEST	PIONEER LABORATORY PIONEER COLD TEST
A	1	R	99	99	96	—	95	92
	2	R	95	94	94	94	97	89
	3	R	92	91	95	—	89	88
	4	F	97	97	99	—	97	95
	5	L	98	98	—	95	—	87
	6	M	99	97	—	92	—	86
	7	R	96	—	94	95	—	82
	8	R	99	—	94	95	—	87
B	1	R	98	94	95	—	96	86
	2	F	93	92	99	—	96	86
	3	R	93	90	94	97	97	90
	4	F	97	95	99	—	97	96
	5	R	96	93	97	—	95	93
C	1	R	94	87	97	—	88	92
	2	F	98	90	100	—	96	96
	3	R	96	95	94	95	92	92
	4	F	98	95	100	—	98	96
D	1	R	99	97	96	—	96	93
	2	R	95	—	92	96	96	92
	3	F	97	97	98	—	98	94
	4	R	94	—	94	94	83	84
	5	R	99	—	93	95	89	90
	6	R	98	—	93	87	94	87
E	1	R	89	—	86	—	—	73
	2	R	90	—	90	—	—	73
	3	F	94	—	—	95	—	82
	4	F	96	—	—	95	—	81
MEAN			96	94	95	94	94	89

TABLE 12. LABORATORY TEST COMPARISONS
GERMANY vs. CANADA

	PIO BUX		Germany ISTA Lab I		Germany ISTA Lab II		AG Canada
LOT #	WT*	CT**	WT	CT	WT	CT	WT
1	99	85	98	94	—	—	98
2	92	93	98	76	96	90	96
3	95	90	97	87	—	—	97
4	95	93	—	—	97	96	—
5	95	89	97	87	—	—	97
6	96	94	—	—	96	93	—
7	94	90	95	85	—	—	95
8	92	94	—	—	97	95	—
9	94	91	98	82	93	90	96
10	93	—	98	62	94	94	96
11	96	92	97	64	—	—	95
12	93	95	—	—	96	92	—
Mean	95	91	97	80	96	93	96

* Warm Test
** Cold Test

TABLE 13. LABORATORY TEST COMPARISONS

		WARM TEST RESULTS				COLD TEST RESULTS		
HYBRID	LOT #	ITALY PRELIM.	ITALY FINAL	USA FINAL	OECD	ITALY PRELIM.	ITALY FINAL	USA FINAL
A	1	96	96	94	98	92	—	96
	2	94	96	97	98	92	—	86
	3	94	93	95	95	68	—	87
	4	98	97	98	98	96	96	92
	5	97	98	97	99	86	94	87
	6	93	95	95	99	68	93	84
B	1	93	93	96	97	90	—	81
	2	93	95	94	97	91	94	84
	3	89	91	91	94	82	—	82
C	1	92	96	96	97	91	93	87

TABLE 14. COMPARISON OF WARM TEST RESULTS FOR LABORATORIES IN SPAIN AND USA

HYBRID	LOT	USA ISA	DIF	USA ISI	DIF	OECD	DIF	SPAIN
A	1	97	+1	94	+4	98	0	98
	2	97	+1	95	+3	99	-1	98
	3	97	+1	96	+2	99	-1	98
	4	96	+2	95	+3	98	0	98
B	1	99	0	98	+1	99	0	99
	2	98	0	97	+1	95	+3	98
	3	98	0	97	+1	96	+2	98
	4	99	-1	96	+2	99	-1	98
	5	98	0	96	+2	98	0	98
	6	99	-1	97	+1	97	+1	98
	7	99	-1	98	0	99	-1	98
	8	99	-1	98	0	98	0	98
	9	99	-1	99	-1	98	0	98
C	1	98	0	98	0	98	0	98
	2	98	0	98	0	98	0	98
			0		+1		0	

COMPARISON ACCORDING TO THE ISA METHOD

35.7% of the lots have equal results in Spain and in the USA.
28.6% of the lots have a higher result in Spain than in the USA.
35.7% of the lots have a lower result in Spain than in the USA.

COMPARISON ACCORDING TO THE ISI METHOD

38.6% of the lots have equal results in Spain and in the USA.
64.2% of the lots have a higher result in Spain than in the USA.
7.1% of the lots have a lower result in Spain than in the USA.

COMPARISON ACCORDING TO THE OECD METHOD

50.0% of the lots have equal results in Spain and in the OECD.
21.4% of the lots have a higher result in Spain than in the OECD.
28.6% of the lots have a lower result in Spain than in the OECD.

TABLE 15. COMPARISON OF WARM TEST RESULTS WITH USA LABORATORIES SPAIN

HYBRID	LOT	USA ISA	DIF	USA ISI	DIF	OECD	DIF	SPAIN
A	1	97	-1	97	-1	97	-1	96
	2	95	+1	95	+1	95	+1	96
	3	98	-2	95	+1	97	-1	96
	4	98	-2	95	+1	98	-2	96
	5	97	-1	93	+3	97	-1	96
	6	98	-2	95	+1	99	-3	96
B	1	99	-3	98	-2	97	-1	96
	2	99	-3	97	-1	99	-3	96
	3	98	-2	96	0	99	-3	96
C	1	96	0	95	+1	97	-1	96
	2	97	-1	94	+2	97	-1	96
	3	98	-2	98	-2	97	-1	96
D	1	97	-1	97	-1	100	-4	96
E	1	96	0	95	+1	97	-1	96
	2	97	-1	96	0	97	-1	96
F	1	98	-2	98	-2	99	-3	96

COMPARISON ACCORDING TO THE ISA METHOD

12.5% of the lots have equal results in Spain and in the USA.
6.2% of the lots have a higher result in Spain than in the USA.
81.3% of the lots have a lower result in Spain than in the USA.

COMPARISON ACCORDING TO THE ISI METHOD

12.5% of the lots have equal results in Spain and in the USA.
50.0% of the lots have a higher result in Spain than in the USA.
37.5% of the lots have a lower result in Spain than in the USA.

COMPARISON ACCORDING TO THE OECD METHOD

0% of the lots have equal results in Spain and in the OECD.
6.3% of the lots have a higher result in Spain than in the OECD.
93.7% of the lots have a lower result in Spain than in the OECD.

TABLE 16. FIELD EMERGENCE TRIAL RESULTS

HYBRID	LOT #	NORMAL	MS A*	MS B**	SEVERE SPLIT	WEAK ROOT	ABNORMAL	DEAD
A	1	90	0	1	1	4	2	2
A	2	83	1	1	3	2	7	4
A	3	96	0	1	0	2	1	0
A	4	97	0	0	0	0	1	1
A	5	85	1	1	3	2	7	2
A	6	88	0	1	2	7	2	1
A	7	86	2	1	3	1	5	3
A	8	88	1	2	2	2	4	2
B	1	84	2	2	2	1	9	1
B	2	87	2	1	3	2	4	2
B	3	97	0	0	0	1	3	0
B	4	83	2	1	3	0	10	1
B	5	92	0	1	2	1	3	2
B	6	90	1	2	1	2	3	3
B	7	83	2	1	6	1	6	2
B	8	80	4	3	3	1	6	3

* MS A = MILD SPLIT A
** MS B = MILD SPLIT B

SEED TESTING: THE VEGETABLE SEED PERSPECTIVE

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The importance of seed testing cannot be over emphasized. In all aspects of production, marketing, and final application of seeds, decisions are made on the basis of the results of laboratory tests of seeds. Whether one considers the value of seed quality in terms of the people dependent on food raised from seed, or the total financial investment in crop production, there is general agreement that seed quality is important.

There is less agreement on how we measure and describe seed quality thus creating opportunities for misunderstandings and financial losses.

It is not within the scope of this paper to recognize the many differences that exist among laboratories in their methods of testing seeds and in the expression of the results of their tests. However, I would like to draw attention to the danger of assuming that the results of all seed tests are comparable, no matter which rules are followed by the laboratories conducting the tests.

Seed certificates produced in the United States are normally white in color. The color of the certificate has no significance. Under International Seed Testing Association (ISTA) rules, the color of the certificate has meaning in reference to the seed lot it represents. The orange ISTA certificate indicates that the seed sample was tested in the same country where the lot is located, and that the testing station was responsible for the sampling, sealing, and labelling of that lot. The green ISTA certificate indicates that the seed sample was tested in a different country than that in which the seed lot is located. A member station in the country where the seed lot is located is responsible for the sampling, sealing, and labelling of the seed lot. Both the orange and green ISTA certificates limit the size of the seed lot. The blue ISTA certificate refers only to a submitted sample, as is the case with most of the seed certificates issued in the United States.

Association of Official Seed Analysts, AOSA, utilizes a four component purity analysis: pure seed, other crop, inert matter and weed seed. ISTA utilizes a three component purity analysis: pure seed, other seed, and inert matter. Both systems use the same number of decimal places in their sample weighing procedures, however, AOSA specifies that two decimal places be used in expressing the percent by weight of each component, while ISTA specifies the use of one decimal place. AOSA does not require weighing the pure seed fraction in a test if the purity working sample size is 25 grams or more. ISTA requires weighing all three components. AOSA and ISTA not only have different definitions for some pure seed units, but also different definitions for pure seed. Pure seed in AOSA is defined as "all seeds of each kind and/or cultivar under consideration which are present in excess of 5% of the whole". ISTA specifies that "pure seed shall refer to the

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species stated by the sender, or found to predominate in the test, and shall include all botanical varieties and cultivars of that species".

Examples of differences in pure seed unit definitions can be found in *Beta vulgaris* L., *Petroselinum crispum* (Miller) Nyman ex A.W. Hill, and *Pisum sativum* L. AOSA uses a visual examination of beet balls to determine if the units are pure seed or inert matter. If the beet ball visibly does not contain a seed, it is classified as inert matter. ISTA uses a sieve for this determination. Units retained by the sieve are pure seed units whether or not a seed is present. AOSA considers only the schizocarp and mericarp the pure unit in *P. crispum,* whereas, in ISTA, the schizocarp and mericarp with or without pedicel are the pure unit. In AOSA, separated cotyledons of *P. sativum* are considered inert matter, irrespective of whether the radicle-plumule axis or more than half of the seed coat is attached. ISTA would consider a single cotyledon of *P. sativum* a pure unit if the radicle-plumule axis or more than half the seed coat remained attached.

There are special procedures in AOSA for determining if weed seed units should be classified as pure weed seed or inert matter. These procedures differ greatly from the procedures applied to pure seed and other crops. In ISTA rules, under most circumstances, seed units (pure seed or other seed) are evaluated by the same set of definitions.

Under AOSA rules, caryopses of weedy *Panicum* species are classified as inert matter if over half the root shoot axis is missing. ISTA classifies caryopses of *Panicum* species that are larger than half the original size as the pure unit. Achenes of weedy *Rumex* species are classified as inert matter if they are devoid of both embryo and endosperm under AOSA rules. The achenes are dissected for this determination. Under ISTA rules, achenes of *Rumex* are pure seed units unless it is obvious that no seed is present. The achenes are not dissected.

AOSA and ISTA purity and other species examination weights may differ. For example, under AOSA rules, the purity sample weight of *Lactuca sativa* L. is three grams and the noxious weed examination is fifty grams, while ISTA rules specify three grams for the purity weight and thirty grams for the other species examination. Another example is *Lycopersicon lycopersicum* (J.) Karsten. While AOSA requires five grams for the purity portion and fifty grams for the noxious weed examination, ISTA uses seven grams for the purity portion and fifteen grams for the other species examination.

In expressing the germination percentage, both AOSA and ISTA use whole numbers, and normally conduct the germination test using 400 seeds in 100-seed replicates. However, many differences do occur. If one of the four 100-seed replicates is out of tolerance, under AOSA rules, one would eliminate the lowest replicate and compute the average based on the remaining three replicates. If the three remaining replicates are within tolerance, their average is the germination percentage reported. Under ISTA rules, if one of the 100-seed replicates is out of tolerance, the results are considered unsatisfactory, are not reported, and a second test is made using the same method. If the average of the second test is compatible with the first test, the average of the two tests shall be reported as the germination percentage.

In some instances, AOSA and ISTA use different seedling evaluation methods. In the evaluation of *Zea mays* L., AOSA rules state that a normal seedling may or may not have a split in the coleoptile. ISTA rules state that a *Z. mays* seedling with a split in the coleoptile more than one third of the length from the tip is classified as abnormal. In the evaluation of *Phaseolus vulgaris* L., garden bean, AOSA states that for a seedling to be classified as normal, it must have at least one complete cotyledon or two broken cotyledons with half or more of the original cotyledon tissue remaining attached. ISTA rules state that at the time of evaluation the cotyledons need not be taken into account for *Phaseolus* if the seedling is otherwise normal. AOSA states that a *Lycopersicon lycopersicum* seedling is classified as normal even if it has no primary root or has a stubby primary root, provided the secondary roots are strong and the hypocotyl is near normal length. ISTA rules state that for a *L. lycopersicum* seedling to be classified as normal, it must possess a well developed primary root and that secondary roots cannot be taken into account in seedling evaluation if the primary root is defective.

The AOSA Germination and Dormancy Subcommittee has initiated a study comparing AOSA and ISTA methods for germination testing of vegetable seed. Dr. Marian Stephenson reports that the germination procedures for 78 percent of the vegetables listed in Table 3 of the AOSA rules differ from the ISTA rules in the temperature, day of first count, or day of final count. In the case of temperature, approximately 54 percent of the vegetables listed in the ISTA rules suggest alternate temperatures where the AOSA rules specify one temperature regime. Substrata specified in the two sets of rules are impossible to compare since ISTA does not distinguish among paper towels, blotters, and filter paper.

All of us are involved in evaluating populations of living entities with their natural variations and continuous deterioration. It is work filled with uncertainties. Employing open-ended test methods to measure ambiguously defined attributes only leads to chaos. To continue to meet the needs of an ever growing population, we must eliminate ambiguous methods of seed testing. Only then can we fulfill our responsibility to evaluate seeds in a consistent and uniform manner.