VIGOUR TESTING OF SEED

A Unit Standard for the Seed Industry

Unit Standard 114667
NQF Level 4
Credits: 14

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Learner Name:
Learner Number:
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### US: Vigour testing of seed

#### Unit Standard Specific Outcomes

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UNIT 1: VIGOUR TESTING OF SEED

1.1 Introduction

Seed vigour is defined by normal seedling morphology as the rate at which seeds germinate and grow in the early stages. Strong seed vigour has many advantages, as vigorous seeds are less likely to be overtaken by diseases, weeds, and insects than weaker ones. For the purpose of this Unit Standard we will give a short explanation of germination before discussing seed vigour and vigour tests.

Throughout this manual the ISTA rules for seed testing was used as the main source of reference. It is important that all the companies where germination tests are conducted are in possession of the latest version of the ISTA rules for reference when performing this test.

1.2 Germination

Germination of a seed in a laboratory test is the emergence and development of the seedling to a stage where the aspects of its essential structures indicates whether or not it is able to develop further into a satisfactory plant under favourable conditions. Seed germination, generally measured by percentage, measures the number of seeds in a lot that can be expected to germinate and grow healthy plants.

Seedlings are classed as normal or abnormal according to internationally agreed definitions, which are experimentally based, and only the former are included in the percentage germination reported. As well as providing a reproducible index on the basis of which trade in seeds can operate and planting value be assessed, it offers a precisely defined baseline for experimental work on seed performance.

1.2.1 Normal seedlings

These seedlings have the potential to grow and develop into physiological mature plants when planted in healthy soil and grown under favourable conditions, such as moisture, temperature and light.

1 International Seed & Testing Association
A seedling must conform to one of the following categories to be classified as normal:

- **Intact seedlings:** Seedlings with all their essential structures well developed, complete in proportion and healthy.

- **Seedlings with slight defects:** Seedlings showing certain slight defects of their essential structures provided they show an otherwise satisfactory and balanced development comparable to that of intact seedlings of the same test.

- **Seedlings with secondary infections:** Seedlings which it is evident would have conformed to 1 or 2 above, but which have been affected by fungi or bacteria from sources other than the parent seed.

### 1.2.2 Abnormal seedlings

Abnormal seedlings do not show the potential to develop into a normal plant when grown in good quality soil and favourable conditions of moisture, temperature and light.

The following seedlings are classified as abnormal:

- **Damage seedlings:** Seedlings with any of the essential structures missing or so badly and irreparably damaged that balanced development cannot be expected.

- **Deformed or unbalanced seedlings:** Seedlings with weak development or physiological disturbances or in which essential structures are deformed or out of proportion.

- **Decayed seedlings:** Seedlings with any of their essential structure so diseased or decayed as a result of primary infection that normal development is prevented.

### 1.2.3 Ungerminated seeds

Seeds which have not germinated by the end of the test period when tested under the conditions given according to ISTA regulations are classified as follows:

- **Hard seeds:** Seeds which remains hard at the end of the test period, because they have not absorbed water.

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2. International Rules for Seed Testing Chapter 5
Fresh seeds: Seeds, other than hard seeds, which have failed to germinate under the conditions of the germination test, but which remain clean and firm and have the potential to develop into a normal seedling.

Dead seeds: Seeds which at the end of the test period are neither hard nor fresh nor have produced any part of a seedling.

1.3 Vigour

The concept of seed vigour is of vital importance to the seed industry because two seed lots with the same germination percentage, but differing vigour could show significant variation in stand and yield when planted under various stress conditions.

It is said that not all facets of seed quality are properly identified by the standard germination test as seed germination measures the number of seeds in a lot that can be expected to germinate and grow healthy plants. Therefore, another aspect of the physiological quality of seeds has been developed called seed vigour. Seed vigour is also defined as "those seed properties which determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions".

Seed vigour tests rank seed lots according to their physiological quality. Vigour test results for a particular seed lot also help to determine the conditions under which it can be successfully planted. High-vigour seed lots may be planted earlier under more stressful field conditions. The results of vigour tests can also be used to decide whether to keep a particular seed lot in storage for a longer period of time. Vigour tests also help isolate possible causes of poor performance of a particular seed lot in the field, which may be beneficial in defending against litigation (ISTA, 1987). Field emergence ability is the major aspect of seed quality that concerns growers, and high germination serves as a prerequisite for seeds to be sown.

1.4 Vigour and viability

Seed longevity is the relationship between viability and vigour. During the time that seed is held in storage, there is a gradual decline in germination and vigour. When the seeds take longer to germinate than usual, the seedlings are smaller, and sometimes malformed. Information about the vigour of a variety can be partially inferred from the germination data if you are familiar with the general relationship between viability and vigour. There are three distinct phases to this relationship:
In the first stage germination is approximately 80% or above and the seed is both vigorous and viable.

The second stage is when deterioration progresses rapidly.

In the third stage deterioration slows at approximately 20% or below, and all seeds will slowly die.

Large differences in vigour and viability are more likely to show up under substandard storage conditions, especially when the relative humidity permits the growth of storage moulds.

1.5 Factors influencing seed vigour

The development process of a seed goes through a series of important stages from fertilization, to accumulation of nutrients, to seed dry down, to dormancy. Each of these stages represents a change in morphological and physiological development that can alter seed performance potential. When a seed achieves its maximum dry weight it is called physiological maturity. At this point, it has its greatest potential for maximum germination and vigour. Since seeds generally achieve physiological maturity at high moisture levels unsafe for storage, seed is typically not harvested until it attains harvest maturity, which is low enough for safe storage, but high enough to minimize mechanical injury. The seed is essentially stored on the plant between physiological maturity and harvest maturity, where it may be exposed to severe environmental conditions that adversely affect seed quality.
Other factors that influence seed vigour are:

The **genetic contents** of the cultivar – each cultivar has its own vigour capacity determined by the cultivar’s genetic content.

**Environmental conditions** during growth as well as during the seed development on the host plant – stress factors such as drought or excessive weed growth, could affect the vigour capacity of the seed.

**Development stages** of seeds during harvesting – seeds harvested before they reached maturity would influence the vigour of the seed.

**Treatment** of seeds after harvesting – the way the drying, cleaning and rating of the seeds are done after harvesting, plays an important role in the vigour of the seed.

**Maturity** of seed - seed is typically not harvested until it reaches harvest maturity, which is low enough for safe storage, but high enough to minimize mechanical injury. A seed achieves its maximum dry weight and it is called physiological maturity. At this point, it has its greatest potential for maximum germination and vigour storage facilities.

**Diseases, chemicals** and the **size** of the seed.
UNIT 2: SEED VIGOUR TESTS

Vigour tests are often species specific and a large number of tests exist. Therefore it is important to select the most suitable test available. Tetrazolium viability tests for example, measure vigour indirectly, and therefore treat vigour as an intrinsic property of the seed. Some, such as physiological stress tests, measure susceptibility to unfavourable conditions directly.

Seed vigour includes the seed properties that determine the potential for rapid uniform emergence and the development of normal seedlings under a wide range of stressful field conditions. In these tests, seed samples are exposed to a stress such as mechanical damage, storage at high temperature and/or humidity, soil pathogens and cold environmental conditions followed by imbibition. After the stress period, the seed sample is germinated under normal growth conditions. The number of uniform well-developed seedlings that germinate indicates the relative seed vigour of the lot.

When the results of a seed vigour test are similar to the germination test results it suggests that the stress treatment was insufficient to overcome seed vigour in that particular lot, and therefore the overall quality of the seed lot is high. Seed vigour test results that are much lower than the germination test suggest the opposite, namely that the stress treatment was sufficient to overcome seed vigour in that lot, and therefore the quality of the seed lot is poor.

The earlier the parameter can be measured during the loss of germination, the more sensitive the index of seed vigour. Since the onset of membrane degradation precedes loss of germination, the most sensitive vigour test should be one that monitors membrane integrity. Membranes are essential for many metabolic events occurring in the seed, including respiration (cristae in mitochondria), which provides the seed with the energy required for subsequent growth. As a result of the biochemical and physiological changes known to occur during seed deterioration, most vigour tests have focused on measuring one or more of these parameters.

Vigour tests aim to measure the ability of the seed to perform well under unfavourable conditions and are used for two main reasons:

- To distinguish between seed lots for suitability for storage.
- To distinguish between seed lots for planting value in relation to optimising establishment.
2.1 Characteristics of a Seed Vigour Test

A vigour test should possess certain essential characteristics that can make it useful to the seed producer and consumer. These characteristics are:

- **Inexpensive** – Because of limited budgets for seed testing, it is essential that a vigour test be reasonably priced and requires a minimum investment in labour, equipment, and supplies.

- **Rapid** – It is important that the vigour test be conducted rapidly to minimize analyst time and germinator space. Moreover, seed producers desire a quick turnaround time for samples submitted for vigour tests since such quick information on seed quality can provide them with a competitive marketing advantage.

- **Uncomplicated** – If possible, vigour test procedures should be uncomplicated so that they can be performed in seed laboratories without requiring additional staff with special backgrounds and training.

- **Objective** - For a vigour test to be easily standardized, a quantitative or numerical index of quality that avoids subjective interpretations by analysts should be utilized.

- **Reproducible** - The success of any test depends on its reproducibility. If these results cannot be repeated because of intricate procedures or subjectivity of interpretation, then comparison of results among laboratories becomes meaningless.

- **Correlated with Field Performance** - The ultimate value of any vigour test may be its ability to predict field performance.

2.2 Seed testing methodology

Seed testing for viability and vigour is essential for describing a seed lot and predicting its germination in the field or greenhouse. Studies in this area have led to the development of unique ways of testing seeds including parameters for stress tests like accelerated aging, cold test, conductivity and methods using digital imaging to provide reliable automated testing.

The vigour tests are not designed to predict the exact number of seedlings that will emerge and survive in the field, even though many of the vigour test results are well related to field emergence. A key purpose of vigour tests is to indicate whether or not trouble may be expected from a high germinating seed lot if the lot is placed under
adverse environmental conditions in the field, storage or during transportation. It is desirable that vigour tests results give reliable information to rank seed lots according to seed quality level and to remove those lots that fall below company standards, since many seed companies have their own in-house vigour test procedures.

2.3 Seed Vigour Testing: ISTA Requirements

The main goal when performing the vigour test is to obtain information about the planting value in a wide range of environments and the storage potential of the seed lot.

Seed vigour definition according to ISTA is the sum of those properties that determine the activity and performance of seed lots of acceptable germination in a wide range of environments. It is a concept which in association with seed lot performance can describe several characteristics of a seed.

- Rate and uniformity of seed germination and seedling growth.
- Emergence ability of seed under unfavourable environmental conditions.
- Performance after storage, particularly the retention of the ability to germinate.

A direct or indirect analytical procedure can be used to evaluate the vigour of a seed lot under standardised conditions.

- Direct test: In this test the environmental stress and other condition are set up in the laboratory and the rate or percentage of seedlings emerging are recorded.
- Indirect test: This test measures other characteristics of the seed that have an influence on some aspects of the seedling performance.

The principle of the test assesses the physiological and physical basis of potential seed lot performance. It is done in a wide range of environments and gives a more sensitive differentiation between seed lots of suitable germination than does the germination test.

A vigour test gives the following information:

- It provides a more sensitive index of seed quality than the standard germination test.
- It provides a reliable ranking of seed lots of acceptable germination in terms of their possible physiological and physical quality.
- It provides information on emergence and storage potential for seed lots to plan marketing strategy.

The seed vigour test methods are very species specific and the following are required:
Suitable equipment

Controlled samples should be used

An experienced analyst to do the test

There are two validated ISTA vigour tests methods that should be used for specific crop types.

- **Conductivity Test for garden peas** (*Pisum sativum*)
- **Accelerated Ageing Test (AA) for Soybean** (*Glycine max*)

### 2.3.1 Conductivity Test

The conductivity test is a biochemical test, which measures the amount of electrolytes, which leach through the seed coat or fruit coat of the intact seed. A higher conductivity may indicate a low vigour seed lot and a low conductivity may indicate a high seed lot vigour. The expected readings for a conductivity test will vary greatly from crop to crop. It is most useful for peas, soybean samples, and a lesser degree for maize.

**Apparatus necessary for this test are:**

- Conductivity meter.
- Erlenmeyer flasks, conical flasks or glass beakers.
- Deionised or distilled water.
- Germinator – incubator or walk-in room.
- Moisture content test facilities.

**Preparation of the sample before measuring conductivity**

The moisture content of the submitted sample should be determined according to the International Rules for Seed Testing and worksite procedures.

**Checking equipment and materials**

- Calibrating the dip cell: A traceable standard solution should be used to calibrate the conductivity meter before starting with the test. It is wise to use at least two solutions with different conductivities. One measuring a conductivity of 100μS cm⁻¹ and the other one between 1000μS cm⁻¹ and 1500μS cm⁻¹.

- Checking the cleanliness of the equipment: A conductivity test should be done on each testing day, by selecting at random 2 flasks to be used and filled with
deionised water with known conductivity. The conductivity of the water should not be higher than 5μS cm⁻¹.

- Checking the temperature: The conductivity test can only be carried out if the temperature of the germinator, incubator or walk in room is according to work site procedures.

Conductivity measurement

- Preparing the test sample
- Preparing the flasks or beakers
- Soaking the seeds
- Preparing for the conductivity readings
- Measuring the conductivity of the solution
- Accounting for the conductivity of the original water source
- Calculating and expression of results

2.3.2 Accelerated Ageing Test (AA)

The AA test is a stress test based on subjecting the seed to conditions based on high temperatures and a high moisture level. High vigour seed lots will withstand these extreme stress conditions and age more slowly than low vigour seed lots. High vigour lots retain a high germination, as where low vigour lots are reduced. The accelerated aging test is used as a vigour test for a wide variety of crops and may also be used to determine storability of seed.

Apparatus used in this test is the following:

- Analytical balance
- Plastic accelerated ageing box
- Bottle top dispenser
- Ageing chamber
- Deionised or distilled water
- Moisture content test facilities
- Germination test facilities
Preparation of the sample

The moisture content of the submitted sample should be determined according to the International Rules for Seed Testing and worksite procedures.

Checking equipment and materials

- Checking the temperature in the ageing chamber: Calibrate the temperature in the ageing chamber according to worksite procedures.
- Cleanliness of equipment: The plastic AA boxes and screen trays should be cleaned before each test according to worksite procedures, to prevent fungal contamination.

Accelerated ageing procedure

- Prepare plastic AA boxes and seed samples
- Age the seed
- Test for germination
- Calculate and express results

2.3.3 Other test methods

A cold test is a stress test based on subjecting the imbibed seed to adverse conditions based on temperature, high moisture level, and soil borne pathogens, in order to determine the vigour level of the seed lot. Seedlings are evaluated for abnormalities at the end of a cold/warm cycle. This test is available for maize, soybeans, sorghum, wheatcorn, soybeans, sorghum, etc.

The vigour, as such, can be evaluated, for example, through enzyme activity, changes in cell membranes organization, and seedling growth rate. These components are regarded as facets of the physiological complex that determine the expression of the physiological potential and to some extent the physical and healthy condition of seeds. Indirect evaluation of cell membrane integrity (electrical conductivity test) has been used intensively in seed vigour testing research. Although those tests have been internationally accepted and standardization has almost been achieved, some refinements of methodology still constitute a challenge for Seed Technology research.
ANNEXURE 1 : REFERENCES

This document does not claim to be an original publication. Various sources of information and documents were used when compiling this document. Any neglect to make reference of any source, including an author, web site or publication is not through intent. Such omissions should be brought to the attention of SANSOR, who will gladly rectify the omission.

International Seed Testing Association (ISTA Rules)

Plant Improvement Act (1976)

www.seedtest.org

www.aosaseed.com

www.seedburo.com
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PURPOSE OF THE UNIT STANDARD
A learner who has achieved this unit standard will be competent in:
Determine the vigour of seed to assess quality.

LEARNING ASSUMED TO BE IN PLACE AND RECOGNITION OF PRIOR LEARNING
To enter a learning programme for this unit standard or to be assessed against this unit standard, the learner is assumed to have:

- Understanding of general safety in the work place at NQF level 3.
- Literacy, numeracy and communication skills at NQF level 3.
- Introduction to the seed industry and relevant workplace.
- Basic computer literacy.
- Basic plant physiology and seed testing principles.

UNIT STANDARD RANGE
The learner is expected to perform the specific outcomes as reflected in this unit standard without direct supervision, but with access to work-site procedures, operating instructions and statutory requirements.

- The learner is expected to be able to analyse the germination of the kinds of seed included in the work site procedure.
- Operational procedures are limited to International Seed Testing Association (ISTA) Rules and Handbooks.
- Equipment refers to, but is not limited to: microscope; magnifying lamp; germination chambers and planting containers.
- Materials refer to, but are not limited to: sub-strata; chemicals and water.
- Peculiarities are limited to: normal and abnormal seedlings; fresh, hard and dead seed.
- Seed testing principles include, but are not limited to: germination-, physical purity-, moisture and viability tests.
- Vigour test method includes but is not limited to: accelerated ageing-, conductivity-, cold-, complex stress- and

UNIT STANDARD OUTCOME HEADER
Specific Outcomes and Assessment Criteria:

SPECIFIC OUTCOME 1
Preparing the work area for conducting a vigour test.

OUTCOME NOTES
- Cleaning and sterilising work area and equipment according to work site-, and operational procedures (ISTA Rules).
- Identifying and selecting appropriate equipment and test methods according to work site procedures and operational procedures.
- Reporting any defects pertaining to appropriate equipment or materials according to work site procedures and operational procedures.

**ASSESSMENT CRITERIA**

**ASSESSMENT CRITERION 1**

Assessors will observe, confirm and evaluate evidence that will indicate that learners have demonstrated competence in each of the specific outcomes. In this unit standard the following specific criteria should be used:

- Consequences of not sub-sampling accurately according to the operational procedures are explained.
- Consequences of not using correct sanitary procedures according to work site procedures are explained.
- Consequences of not identifying and reporting findings accurately according to the operational procedures and work site procedures are explained.
- Consequences of not reporting deviations are explained.
- The importance of using the correct equipment, sub-strata and methods for planting and evaluating according to work site procedures are explained.
- The importance of recording the different fractions according to the operational procedures and work site procedures are explained.
- The importance of retaining the sample and prescribed records according operational procedures, work site procedures and statutory requirements are explained.

**SPECIFIC OUTCOME 2**

Prepare sample and relevant documentation.

**OUTCOME NOTES**

- Familiarising with the peculiarities of the specific crop type regarding vigour testing method requirements according to operational procedures and work site procedures.
- Acquiring the working sample according to work site and operational procedures.
- Preparing relevant documentation to record action taken.
- Preparing the seeds according to relevant method, operational- and work site procedures.
- Returning the balance of the working sample according to operational procedures and work site procedures.
- Complete relevant documentation according to work site- and operational procedures.

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The importance of recording the different fractions according to the operational procedures and work site procedures are explained.

The importance of retaining the sample and prescribed records according operational procedures, work site procedures and statutory requirements are explained.

SPECIFIC OUTCOME 3
Conduct the vigour test.

OUTCOME NOTES

Preparing the equipment and material relevant to the method, work site- and operational procedures.

Conducting the test according to the relevant method, work site- and operational procedures.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
Assessors will observe, confirm and evaluate evidence that will indicate that learners have demonstrated competence in each of the specific outcomes. In this unit standard the following specific criteria should be used:

Consequences of not sub-sampling accurately according to the operational procedures are explained.

Consequences of not using correct sanitary procedures according to work site procedures are explained.

Consequences of not identifying and reporting findings accurately according to the operational procedures and work site procedures are explained.

Consequences of not reporting deviations are explained.

The importance of using the correct equipment, sub-strata and methods for planting and evaluating according to work site procedures are explained.

The importance of recording the different fractions according to the operational procedures and work site procedures are explained.

The importance of retaining the sample and prescribed records according operational procedures, work site procedures and statutory requirements are explained.
SPECIFIC OUTCOME 4
Evaluate the vigour test.

OUTCOME NOTES
- Making an assessment of the particular result according to work site- and operational procedures.
- Familiarising with the peculiarities of variations of the results of the specific tests.
- Appraising the sample at the relevant evaluation intervals according to work site- and operational procedures.
- Recording findings and deviations according to work site- and operational procedures.

ASSESSMENT CRITERIA
ASSESSMENT CRITERION 1
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- The importance of using the correct equipment, sub-strata and methods for planting and evaluating according to work site procedures are explained
- The importance of recording the different fractions according to the operational procedures and work site procedures are explained.
- The importance of retaining the sample and prescribed records according operational procedures, work site procedures and statutory requirements are explained.

SPECIFIC OUTCOME 5
Complete the process.

OUTCOME NOTES
- Restoring the work area according to operational procedures and work site procedures.
- Completing and retaining documentation and informing relevant parties according to work site- and operational procedures.

ASSESSMENT CRITERIA
ASSESSMENT CRITERION 1
Assessors will observe, confirm and evaluate evidence that will indicate that learners have demonstrated competence in each of the specific outcomes. In this unit standard the following specific criteria should be used:

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- The importance of retaining the sample and prescribed records according to the operational procedures, work site procedures and statutory requirements are explained.

UNIT STANDARD ACCREDITATION AND MODERATION OPTIONS

An individual wishing to be assessed against this unit standard may apply to an assessor accredited by SETASA.

Any training provider offering learning that will enable achievement of this unit standard must be registered and accredited by SETASA.

Moderation of assessment will be done by SETASA in its ETQA capacity at its discretion.

UNIT STANDARD ESSENTIAL EMBEDDED KNOWLEDGE

- General knowledge of the differences between germinating and non-germinating seed, as well as normal and abnormal seedlings; fresh, hard and dead seed.
- Knowledge and theory of operation of microscopes, growth cabinets and seed-counting equipment.

UNIT STANDARD DEVELOPMENTAL OUTCOME

UNIT STANDARD LINKAGES

Critical Cross-field Outcomes (CCFO):

UNIT STANDARD CCFO IDENTIFYING

Identify and solve problems by assessing and reporting the germination of seed.

UNIT STANDARD CCFO WORKING

Work effectively with others with whom the relevant function interfaces.

UNIT STANDARD CCFO ORGANIZING

Organise and manage oneself when preparing for analysis of the germination of seed.

UNIT STANDARD CCFO COLLECTING

Collect, analyse, organise and critically evaluate the information documents, samples and condition of work site.
UNIT STANDARD CCFO COMMUNICATING
Communicate with others in the process of the analysis of the germination of seed.

UNIT STANDARD CCFO DEMONSTRATING
Understand the world as a set of related systems in appreciating the importance of accurate analysis, identification of abnormalities, irregularities and defects and the consequences of not reporting these with regard to the analysis of the germination of seed.

UNIT STANDARD ASSESSOR CRITERIA

UNIT STANDARD NOTES
Values All learners should demonstrate:
An application of company ethics, values as well as general safety and customer care principles.
An awareness of expectations and obligations of basic worker / management / customer relationships.