Seed Testing: Key to Establishing and Maintaining Seed Quality Standards

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ABSTRACT

Seed testing is a crucial process undertaken to ensure the quality, viability, and genetic purity of seeds before they are sown. This evaluation helps in determining factors such as germination rate, moisture, vigour, disease resistance, and genetic identity. By conducting seed testing, farmers, seed producers, and researchers can make informed decisions regarding seed selection, storage, and planting practices, thereby maximizing crop yield, maintaining consistency in crop performance, and safeguarding agricultural productivity. In India, seed testing primarily focuses on evaluating the moisture content, germination potential, and physical purity of seeds. This quality assessment is conducted using small samples drawn from larger seed lots intended for cultivation. The amount of seed sample analyzed in laboratories is significantly smaller in comparison to the total seed batch it represents.

INTRODUCTION

Seed testing involves assessing various aspects of a seed lot, such as its physical purity, moisture content, germination rate, and other seed vigour indicators. This process is essential as it ensures that the farming community receives high-quality seeds. Seed Testing Laboratories play a pivotal role in maintaining seed quality control by providing necessary services to determine the planting potential of seed lots. These services are indispensable for seed producers, sellers, and users alike, offering valuable insights into the quality and reliability of seeds. Over a century ago, the significance of seed testing became evident in ensuring reliable planting outcomes. Instances of

adulteration, such as the inclusion of stone dust in vegetable seeds, were reported in certain regions, notably Europe. The universally accepted quality standard is the germination test conducted according to specified guidelines, where the number of healthy seedlings determines the germination rate (ISTA, 2010). The evolution of seed testing has since played a crucial role in agricultural practices by providing essential information about various quality parameters such as purity, moisture content, germination rate, seed vigour, and overall health. These advancements aim to mitigate potential risks in crop production and support informed decisions throughout the agricultural sector.

Role of Seed Testing Laboratory

Upon receiving seed samples at the laboratory, known as submitted samples, it is necessary to reduce them to obtain working samples for conducting various tests. Several methods are available for this purpose. Seed testing laboratories play a crucial role in seed certification and quality control programs. Their primary objective is to provide information on seed quality to benefit producers, consumers, and the seed industry. Test results can lead to the rejection of poorly multiplied seeds or seeds of low grade as per legal standards. Laboratory analysis of seeds involves specialized and technical procedures. To ensure consistent quality control, seed analysis laboratories typically comprise four distinct sections. The purity testing section evaluates seed lots based on two main factors: assessing the cleanliness of the seeds and verifying the authenticity of the cultivar. Other sections include moisture testing, viability and germination testing, and vigour testing. These sections collectively support the thorough evaluation and certification of seed quality for all stakeholders involved in seed production, sale, and utilization.

Sampling in Seed Testing Laboratory

Upon arrival at the laboratory, seed samples (referred to as submitted samples) must undergo reduction to create working samples suitable for conducting a range of tests. Various techniques exist for obtaining these working samples efficiently.

Mixing and dividing of seeds

Mixing and dividing seeds aims to achieve a representative and uniform sample suitable for analysis by reducing the submitted sample to the required size of the working sample. This process ensures that the sample used for testing accurately reflects the composition of the original seed batch.

Method of mixing and dividing

1. Mechanical dividing
2. Modified halving method
3. Hand halving method
4. Random cup method
5. Spoon method

1. **Mechanical dividing method:** Mechanical dividers are used to reduce the sample size, and they are effective for most seeds except those that are chaffy or fuzzy in nature. These devices ensure that the sample is appropriately sized for testing purposes, maintaining accuracy in seed analysis procedures**.**

Types of mechanical dividers

a. **Boerner divider:** This device comprises a hopper, a cone, and a series of baffles that guide seeds into two separate spouts. The baffles are evenly sized and evenly spaced around a circular arrangement, directing seeds inward, with every other baffle leading to one of the spouts. At the base of the hopper, a valve controls the release of

seeds; upon opening, seeds flow by gravity onto the cone, where they are evenly distributed, ensuring roughly equal quantities are collected in each spout. One drawback of this divider is its limited capability to assess seed cleanliness effectively.

b. **Soil divider:** This sample divider operates based on the principles similar to the Boerner divider but with channels arranged in a linear configuration. It includes a hopper with attached channels, a framework to support the hopper, two pans for receiving divided seeds, and a pouring pan. This design is particularly effective for handling large seeds and those with chaff, ensuring efficient and accurate division of seed samples for analysis.

c. **Centrifugal or Gamet divider:** This method utilizes centrifugal force to both mix and divide seeds. Seeds are deposited onto a shallow rubber spinner that, when rotated by an electric motor, expels them outward due to centrifugal force. A stationary baffle divides the circular area where seeds land into two equal parts, ensuring that approximately equal amounts of seeds are directed into each spout

2. **Modified halving method:** This device includes a tray with a grid composed of uniformly sized cubical cups, each open at the top, with every other cup lacking a bottom. After initial mixing, the seeds are evenly distributed across the grid. Upon lifting the grid, roughly half of the sample remains on the tray. This process is repeated successively to halve the submitted sample until the desired working sample size is achieved.

3. **Random cup method:** This technique is applicable to seeds needing a working sample size of up to 10 grams, as long as they are not excessively chaffy or prone to bouncing or rolling, such as Brassica spp. Six to eight small cups are randomly positioned on a tray. Following initial mixing, the seeds are evenly spread across the tray. The seeds that fall into the cups are collected and used as the working sample.

4. **Hand halving method:** This technique is specifically designed for chaffy seeds. Initially, the seeds are evenly distributed on a smooth, clean surface and thoroughly blended into a mound. The mound is divided in half, and each half is formed into a new mound, then halved again to create four portions. These portions are further divided into eight portions, which are then arranged in rows. Alternating portions are combined and retained, and this process continues until the desired weight of the sample is achieved.

5. **Spoon method:** This method is appropriate for samples consisting of single small-seeded species. It necessitates a tray, a spatula, and a spoon with a straight edge. Following initial mixing, the seeds are uniformly distributed over the tray. The tray should remain undisturbed thereafter. Using the spoon in one hand and the spatula in the other, small portions of seeds are carefully taken from at least five random spots on the tray. These portions are collected in quantities sufficient to estimate a working sample size that meets or exceeds the required amount.

Determination of Physical Purity

In the seed testing laboratory, purity analysis involves identifying and quantifying various components of a seed sample: pure seeds, seeds from other crops, weed seeds, and inert material. The goal of purity analysis is to assess whether the submitted sample meets the specified physical quality standards regarding its constituent components. Typically, a working sample of specified weight is extracted from the submitted sample for analysis. This analysis can be performed on a single working sample of the designated

weight or on two sub-samples, each weighing at least half of the designated weight, drawn independently. After weighing, the working sample is divided into its components—pure seeds, seeds from other crops, weed seeds, and inert matter.

Method of purity separation

After completing the sieving or blowing procedures, place the sample on the purity work board and segregate it into other crop seeds and inert material. Once separated, categorize each type of weed seeds and other crop seeds by their genus and species. Record the names and quantify each identified seed type accordingly. Additionally, identify and document the specific types of inert matter present in the sample.

Pure seed refers to seeds of the specified kind or species as indicated by the sender, encompassing all botanical varieties within that category. This category also includes immature, undersized, shrivelled, diseased, or germinated seeds. Additionally, broken seeds are considered pure if each piece is larger than half of the original size, except for legumes and cruciferous seeds where seeds without their seed coat are classified as inert matter. Other crop seed denotes seeds from crops other than the specific kind under examination. Weed seeds encompass species typically recognized as weeds or those designated as noxious under relevant seed legislation. Inert matter encompasses various non-seed components such as seed-like structures, stem fragments, leaves, sand and stone particles, empty husks and glumes, lemma and palea structures, chaff, awns, and stalks longer than florets and spikelets.

Seed germination test

The seed germination test assesses the emergence and growth of essential seed structures specific to each seed type, indicating its capacity to develop into a healthy plant under favourable conditions. To conduct the test, a pure seed sample is used, comprising a minimum of 400 seeds distributed across four replicates of 100 seeds each, or alternatively, in eight replicates of 50 seeds each, or sixteen replicates of 25 seeds each, depending on seed size and container capacity. The test conditions include optimal moisture, temperature, appropriate substrate, and, if necessary, suitable light conditions. Seeds undergo no pretreatment unless specifically recommended by ISTA guidelines. Materials required for conducting seed germination tests include substrates such as sand, germination paper, and soil. Sand serves as a moisture reservoir and growth medium, with particles sized to pass through a 0.80 mm sieve but retained by a 0.05 mm sieve to ensure optimal conditions. It must be free from toxic substances and pathogens; contaminated sand should be sterilized before use.

Germination trays, typically zinc or stainless steel and measuring 22.5 x 22.5 x 4 cm, are used for seeding. Seeds are placed uniformly in moist sand, covered to a depth of 1 to 2 cm, or placed on the sand surface. For seeds that require light during germination, they are positioned on one or more layers of damp filter paper or blotter paper within petri dishes. These dishes are then sealed with lids and placed inside a germination chamber to facilitate optimal conditions for growth. Proper spacing ensures healthy seedling growth and prevents disease spread. Water levels in the sand vary by seed size, with cereals requiring 50% of the sand's water holding capacity and large legumes like maize needing 60%. Filter paper substrates, like filter or blotter paper, are also commonly used, providing capillary action for moisture movement and ensuring seedlings grow on the surface without rooting into the paper.

Germination room: This facility, known as a chamber, enables precise control of temperature, relative humidity, and lighting

conditions tailored to the specific needs of different crops.

Room germinator: Operating on the same principles as a germinator, this chamber is an enhanced version, larger in size, and designed for workers to enter and assess seedlings. It is equipped to regulate temperature and relative humidity, making it a widely utilized tool in practical applications**.**

Seed counting board: This device is employed for precise seed counting and spacing. It comprises two plates: a stationary basal plate and a movable top plate, each equipped with a uniform number of holes, typically 50 or 100, depending on their configuration. After placing the sample, the top plate is adjusted so that its holes align, allowing a predetermined number of seeds to drop onto the substrate below.

Vacuum seed counter: This equipment includes a head, pipe, and wall, along with plates featuring either 50 or 100 holes that can be attached to the head. When a vacuum is generated, the plate attracts seeds, and upon releasing the vacuum, the seeds are deposited onto the substrate.

Impression board: Constructed from plastic or wood, this tool is equipped with either 50 or 100 holes or pins. The knobs are evenly distributed in length and spacing along the tool. When pressed into sand, it ensures consistent depth and spacing for planting seeds.

Evaluation of germination test

During the germination test, the evaluation includes categorizing seedlings into those that are normal, abnormal, and hard, as well as identifying fresh seeds that have not germinated and seeds that are no longer viable.

Characteristics of normal seedlings

During seed germination, the evaluation criteria include a robust root system featuring a primary root, except in certain graminae species that typically produce seminal or secondary roots. Seedlings with epigeal germination exhibit a well-developed shoot axis characterized by elongated hypocotyls, while those with hypogeal germination display a well-developed epicotyl. Monocotyledonous plants typically have one cotyledon, whereas dicotyledons have two. Graminae seedlings show a well-formed coleoptile containing a green leaf, while dicotyledons exhibit a well-developed plumule. Seedlings exhibiting minor imperfections are still classified as normal. These include instances where the primary root may have limited damage, yet secondary roots are well-developed, observed in leguminous plants like *Phaseolus* and *Pisum*, graminae species such as Maize, cucurbitaceous plants like Cucumis, and members of the Malvaceae family such as cotton. Seedlings showing limited damage or decay to essential structures, without affecting conducting tissues, also fall under this category. Additionally, seedlings affected by pathogenic decay are considered normal if clear evidence shows that the infection did not originate from the parent seed.

Moisture content determination

The objective of determining seed moisture content is to measure the amount of moisture present using methods suitable for regular application. The moisture content of a seed sample is defined as the percentage of weight lost when the sample is dried. This factor is crucial for maintaining seed quality. Two main methods are employed: the air oven method, where seeds are dried at a specific temperature for a set period, and moisture meters, which provide quick estimates but with less precision than the air oven method. Depending on the species, 100 grams of sample are required for

species that need grinding, while 50 grams suffice for others. Samples should be submitted in a 700-gauge polythene bag.

Retesting

If the results from a germination test are deemed unsatisfactory, they will not be reported, and a second test will be conducted using the same method or an alternative approach under specific circumstances. These include instances where replicate performance deviates beyond acceptable tolerance limits, inaccuracies arise due to errors in seedling evaluation, counting, or test conditions, or when factors like seed dormancy, phytotoxicity, or fungal and bacterial contamination affect results. The average of the two test results will then be reported. To ensure reliability, the difference between the highest and lowest replicates must fall within established tolerance thresholds for a germination test result to be considered valid. Tolerance tables are utilized to determine the compatibility of results from two tests conducted on the same sample. The final reported germination test result is the average percentage of normal seedlings across four sets of 100 seeds each, rounded to the nearest whole number. Percentages of abnormal seedlings, hard seeds, fresh seeds that failed to germinate, and dead seeds are calculated similarly and recorded in the appropriate sections of the analysis certificate. If any of these categories yield a result of 'nil,' it is reported as '0'.

Key features of seed testing

1. **Purity Analysis:** Determines the percentage of pure seeds, other crop seeds, weed seeds, and inert matter in a seed sample.
2. **Germination Testing:** Assesses the ability of seeds to germinate under controlled conditions, providing insights into seed viability and vigour.
3. **Moisture Content:** Measures the amount of moisture present in seeds, crucial for determining storage suitability and preventing fungal growth.
4. **Seed Health:** Identifies seed-borne pathogens and diseases, ensuring the production and distribution of disease-free seeds.
5. **Genetic Identity:** Confirms the genetic purity of seeds, ensuring they meet varietal standards and regulatory requirements.
6. **Physical Attributes:** Evaluates seed size, weight, shape, and colour, which are important for seed handling, planting machinery calibration, and uniformity in planting.
7. **Seed Treatments:** Tests the effectiveness of seed treatments such as fungicides and insecticides, ensuring they enhance seed health without affecting germination.
8. **Documentation and Certification:** Provides official documentation and certification of seed quality, essential for trade and regulatory compliance.
9. **Research and Development Support:** Provides data on seed traits and performance, supporting breeding programs and the development of new cultivars.
10. **Quality Assurance:** Ensures consistency and reliability in seed performance, supporting sustainable agriculture practices and enhancing farmer confidence.

International standardization

The primary goal of the International Seed Testing Association (ISTA) is to promote and implement globally standardized methods for seed testing, focusing particularly on achieving

consistency in procedures. One successful example is the establishment of a standard germination test, where the emergence timing of the radicle has been emphasized to develop faster evaluation methods. In maize, international comparative trials have confirmed the reliability within and between laboratories regarding radicle emergence timing (Matthews *et al*., 2011). This effort has led to the proposal of a vigour test for maize within a standard germination test, completed in less than three days (Matthews *et al*., 2011), which has been validated by ISTA. Similar approaches may be applicable to other plant species. There is considerable interest in advancing techniques and tools for swift and automated assessment of seed quality. Computer imaging techniques, as emphasized by Dell'Aquila (2007), are currently garnering considerable attention, especially in assessing the early stages of germination (Ducournau *et al*., 2005). However, these methods must undergo thorough testing across various laboratories using commercially available seeds before they can be universally adopted

CONCLUSION

Seed testing plays a pivotal role in modern agriculture by ensuring the quality, purity, and viability of seeds. By evaluating various parameters such as purity, germination potential, moisture content, and seed health, seed testing provides essential information that farmers and seed producers rely on to make informed decisions. This process not only safeguards against the spread of diseases and pathogens but also supports sustainable farming practices by optimizing seed selection, planting practices, and crop performance. Ultimately, seed testing contributes to enhancing agricultural productivity, improving food security, and fostering trust and reliability throughout the global seed industry.

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