SEED MULTIPLICATION, TESTING AND CERTIFICATION

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I. INTRODUCTION

Plant breeders usually work ten years or longer to develop an outstanding new crop variety. This new variety is thus the end production of years of painstaking efforts of many agricultural workers. But, this new variety with all its superior plant characters will not automatically maintain the way it was developed. It may get badly mixed with weeds, other crops or other varieties of the same crop and then lost its own identity. Or it may cross-pollinated with other kinds of crops or other varieties and become genetically different from the original variety the breeders developed through years of hardwork. In time, it might not even look like the new variety released only a few years ago.

A new superior variety will lose its practical farming value through mixing with other things. A slight mixing with other varieties may not make much difference in yield. But with further mixing, a farmer can't be certain whether or not he's planting the recommended variety. This is true enough though he may know the seed germinates satisfactorily and is free of weed and disease contamination. The following are two most common occurrences that a superior variety would lose its own identity gradually:

(1) Self-pollinated crops don't do much crossing, there's not much danger of contaminating a new variety with pollen of other varieties many hundred meters away. The main concern in preserving its purity is to prevent mechanical mixing. Mechanical mixing is likely to occur in so many possible ways -- such as from drying ground, processing equipments, bags, and storaging facilities. Mixtures also occur mechanically in the field -- from manure and compost; from seeds remained in the field by previous crops, from seed nursery where seeds of two or more than two varieties are sowed in the neighborhood.

(2) Cross-pollinated crops, such as corn, sorghum and forage crops, are naturally cross-pollinated. Their pollen may be blown by the wind for many hundreds or thousands meters and still remain potent. Bees and other insects cross-pollinate many crops too. Thus, different varieties of such crops must be separated by much greater distances than the self-pollinated crops in order to avoid deterioration genetically of the new variety. These relatively great distances have been found necessary to keep these cross-pollinated crops pure.

By well designed and planned system of seed multiplication and certification, the new superior variety will be able to preserve its genetic identity and varietal purity for many years.

II. Seed Multiplication

A. Foundation Seed Program

It was recognized that new and better varieties had value only as they got into the hands of farmer growers to be planted extensively, and only if they retained the same genetic identity and superior general characteristics developed by the breeder. It was further recognized that, whatever the crop might be, the seed supplies must be increased to a sizeable quantity before they could be released in a satisfactory way to growers generally.

As a general practice in many developing countries, the seed increase work of a new crop or variety, was handled by the experiment station in which the crop or variety had been developed. There were certain advantages to this method in that the personnel responsible for the newly developed variety was in close contact with their product during the period of seed increase. But it tended to interfere with research, and most experiment stations had neither the personnel nor facilities and funds to carry on a large increase program.

The aim and purpose of a foundation seed program is to implement commercial certified seed production. The seed should meet high standards of purity and germination and represent germ plasm distinctly superior to existing commercial varieties in one or more characteristics. This program should result in high quality seed at a reasonable price and in volume justified by the superiority of the variety. A foundation seed program is to the plant breeder the equivalent of a skilled and dependable technical assistant, thus giving him more time for scientific development of new varieties. It is through this program, the plant breeder witness the multiplication in large scale production of his new crop variety, which he has spent many years in developing, in a relatively short period of time and containing the same degree of genetic purity as when released. Likewise it is this same program which the ordinary seed producers can depend on as a source of seed in its purest state of both new and old crop varieties, to perpetuate his production of high quality seed for general distribution.

Foundation seed program is administered in several different ways. They can be divided into three general categories:

(1) Completely public -- Stock seed is produced under the direct auspices of the agronomy department or experiment station or is supervised by the college. Breeder seed is increased on land controlled by the experiment station or by contract with a private grower.

(2) Semi-public, in which private groups, either seed industry or grower members, work cooperatively with the experiment station.

(3) Completely private.

The business and affairs of the foundation seed stock organization should be conducted under the overall control of a board of directors. The technical supervision of increasing and processing foundation seed should be done by a staff member of manager in accordance with the policies established by the directors. The increasing and processing of foundation seed is highly technical and requires personnel especially trained in this field. The operation of a foundation seedstocks organization, to be successful, must be integrated closely with research, extension service and other related groups. Its personnel need guidance from the research staffs not only in obtaining an early supply of the improved germ plasm but also in newer methods and techniques used in its production and processing. Close association with the extension personnel results in the development and selection of the best cooperators and in informing the public of the performance and availability of the new variety that is to be released.

Methods used in allocating seed to growers: The following policies should always be followed:

(1) only qualified producers are alloted seed;
(2) releases are made only to adapted areas;
(3) certification is required;
(4) foundation seed is handled under supervision of agricultural experiment station;
(5) every grower should have the opportunity to secure seed of improved varieties as early as possible.

A non-profit crop improvement organization is usually entrusted to recommend list of names from which to select cooperators or to be entrusted to select growers directly for the production of certified seeds.

The purposes and function of the foundation seed program can be summarized as follows:

1. The purpose of a seed stocks program is to assist in increasing and making available, efficiently and economically, genetically pure seed of desirable varieties, both new and old, to growers of certified seed.

2. Only breeder seed either produced and preserved by the Foundation Seed Agency itself or by the agricultural experiment station will be used for the production of foundation seed.

3. The foundation seed agency will work closely with the seed certification agency, the agricultural experiment station and other related organizations. The seed certification agency is in a good position to make recommendation of capable and qualified growers for the production of foundation seed. It is highly important that the growers have a thorough knowledge of the crop and of approved agronomic and processing practices which are consistent with the production and marketing of high quality seed.

4. The number of growers for a specific crop or variety should be few, but enough to make it possible to produce the seed in more than one section of the district. This is necessary to lessen the possibility of crop failure and consequent loss of valuable breeder seed.

5. Foundation seed agency must keep close surveillance over all seed produced.

6. The amount of foundation seed of any crop must be determined by the demand.

7. Distribution of foundation seed must be fair and equitable.

B. Classes of seed:

When a superior new crop variety is developed and multiplied, some planned method must be followed whereby the genetic identity and purity of the variety can be safeguarded. Otherwise, there would be a grave danger that improved varieties would become lost for all practical purposes. In many countries this is done by limiting the seed production to a restricted number of generations. When this generation system is applied, the certified seed will stem directly from a breeder seed lot and must be not more than a small number of generations removed from the original seed stock. In Taiwan, four classes of seed have been recognized in seed certification, namely:

1. Breeder Seed: It is the limited amount of seed used by the plant breeder in actually breeding or maintaining a strain or variety. It is always under the direct supervision and control of the plant breeder and never available for sale and use by the general public. Breeder seed is used for the production of foundation seed. The increase and preservation of breeder seed can best be handled by a foundation seed agency.

2. Foundation Seed: It is the seed stock that are so handled as to most nearly maintain specific genetic identity and purity and that may be designated or distributed by an agricultural experiment station. Foundation seed shall be the source of all other certified seed classes, either directly or through registered seed.

   The following is an example of how to produce foundation seed of small grain:

   (1) Careful selection of heads or panicles from a foundation seed farm according to varietal head and seed characteristics. The number of heads varies according to needs, but usually ranges between 1,000 to 5,000;

   (2) Planting head rows or hills;

   (3) Repeated roguing of head rows. All rows or hills containing off-type plants or any other doubtful plants are completely eliminated.

   (4) Bulk harvesting of head rows.

(5) Seeding of head row seeds.

(6) Repeated roguing. The importance of trained personnel and of systematic roguing cannot be over emphasized.

(7) Bulk harvesting of increased fields.

(8) Careful and separate cleaning, treating, bagging (in new bags) and tagging of seeds.

Foundation seed production and distribution should be under the control of the agricultural experiment stations, or any other seed control agencies. The sale of foundation seed should be restricted to registered seed producers except in varieties where the registered seed class has been eliminated. Registered seed growers must order foundation seed in advance, because the amount of foundation seed to be produced are usually small for each variety.

3. Registered Seed: It is the progeny of foundation or registered seed that is so handled as to maintain satisfactory genetic identity and purity and that has been approved and certified by the certifying agency. This class of seed is of a quality suitable for the production of certified seed.

The selection of registered seed producers should be based on satisfactory record of certified seed production. This classification is open to all growers who have the essential facilities for quality seed production and who meet with a standard set of requirements.

The entire production of registered seed, within reasonable limits, is intended for certified seed production. All registered seed must be kept in new clean bags, labeled and properly sealed. Measures should be taken to avoid concentration of registered seed in the hands of any one individual or concern, by stipulating in the agreement that the producer can only retain a certain percent of his product (registered seed) and make the remaining portion of their production available to others for certified seed production.

4. Certified Seed: It is the progeny of foundation, registered, or certified seed that is so handled as to maintain satisfactory genetical identity and purity, and that has been approved by the certifying agency.

In many countries, for certain kinds of crops (mostly self-pollinated crops), first and second generations of the certified seed are used.

The production of certified seed is open to anyone who agrees to comply with rules and regulations established by the certifying agency. Growers of good reputation are preferred. There are no restrictions on the volume of certified seed production. Certified seed must be distributed in clean, or new bags.

III. PURPOSES OF SEED CERTIFICATION

The object of seed certification is to maintain and to make available to growers high-quality seeds and propagating materials of superior crop varieties, so grown and handled as to ensure authenticity and genetic purity and as high a standard of seed quality as possible. In other words, the purpose of seed certification is to give the consumer an assurance regarding some important points of quality which cannot be determined readily by an examination of the seed itself.

Varietal purity is the first consideration in seed certification but other factors such as weeds, diseases, viability, mechanical purity and grading are important in providing a seed product which the grower can plant with reasonable assurance that he can and will obtain a good stand of healthy plants of the desired variety without introducing undesirable competitive plants or disease hazards.

Seed certification is designed to maintain not only genetic purity of superior crop varieties but also to maintain reasonable standards of seed condition and quality.

IV. CERTIFYING AGENCIES

Seed certification is a responsiblity of the states. Authority to carry on this service is given by legislation to an agency or organization whose responsibility for the work is defined in the law.

Certification should be conducted either by a governmental agency or by an incorporated non-profit organization of seed growers. The agency should have a close working relationship with seed growers and agricultural research, extension and seed regulatory services. A seed certifying agency is able to do the following:

1. Relieve the burden of maintaining crops seed purity off the shoulders of the plant breeders.

2. Give research men more time to develop newer varieties.

3. To make available high quality seeds to the farmers.

4. To select qualified seed growers to receive a small quantity of the breeder's seeds of a new variety.

A. Types of seed certifying agency: At least three types of certifying agencies are found in many countries:

1. Agricultural Experiment Station: Agricultural experiment station is primarily for the improvement of agriculture. Newer, better varieties of crops, vegetables and other valuable plants are bred and experimented for public cultivation. Cultural methods are improved. Diseases and pests of crops are studied and controlled. In most of the countries, foundation seeds of the important crops are generally carefully produced by agricultural experiment stations to maintain and insure the utmost quality and varietal purity the foundation seeds required. The foundation seeds are also officially inspected and certified before they are allowed to be distributed. In case the agricultural experiment station is designated by government as a seed certifying agency, a section is usually created under the station to handle the certification works, because the technical staff of the station are too fully occupied to take care of the seed multiplication and certification program too. Helps from local government agencies, such as the department of agriculture, is always needed in preparing rules and regulations governing seed certification and the minimum seed standards for various kinds of crops.

2. Department of Agriculture: In many countries, government agencies take up the work of seed multiplication and certification. All applications for certifying seeds are going to the State Department of Agriculture for screening and inspection. Therefore, in many agriculture developing countries, when the government started its seed multiplication and certification program, beside all the technical difficulties, the financial burden is likely to be shouldered only by the government herself. Because the seed growers with their small land holdings, and not always operated efficiently, can not pay for the services of certifying their seed to the government agency. Their businesses are usually small and their profits are small too. In those countries, ordinary farmers always see the value of good seeds, especially when those good seeds are priced higher. With the funds appropriated by the government, the seed certification program can be put into practice right away without minding too much about the financial problems. In Taiwan, a Seed Technology Section within the organization of the Provincial Department of Agriculture and Forestry is designated as the official seed certifying agency. In the Section, there are seven field inspectors, and one seed testing laboratory where a staff of five seed analysts are working. The seed testing laboratory is working on 4,000 seed samples of 17

different kinds of crops (field crops and vegetables) a year. Applications for certification are sent directly from seed growers to the Seed Technology Section. The following is the conditions to be met by vegetable seed growers in Taiwan in applying for seed certification:

1. Only those kinds of vegetable seed for export are now eligible for certification.
2. The kinds and varieties of crops to be certified are only those listed in the regulations.
3. Application must be handed in before November 15.
4. Vegetable seed growers must contract with seed companies for certification.
5. A vegetable seed farm must have an area of no less than 0.2 ha.
6. Seed farms must erect a sign in the field to indicate farmer's name, crop variety, planted area, and date of sowing.

3. Crop Improvement Association: It is an organization organized by seed companies, merchants and those who are interested in promotion of seed industry. It serves as a medium between seedsmen and farmers, seed growers and seed distributors, agricultural researchers and ordinary cultivators. It represents seed industry in giving expression to their ideas and views about crop improvement. It affords a better opportunity of learning the whys and wherefores about standard crop requirements. The purposes of the association are as follows:

(1) To promote the production, identification, distribution, and use of certified seed and other propagating materials of superior crop varieties.

(2) To establish minimum standards of seed production, storage and handling.

(3) Standardization of certification requirements and procedures to the end that all certified seed will be as good or better than an accepted, minimum standard of quality.

(4) To inform the public as to the value of certified seed and encourage its wide-scale use through approved educational media.

(5) To develop cooperation with all individuals, groups and organizations directly or indirectly interested in the improvement of crops.

(6) To sponsor crop improvement programs, pest control programs for the general improvement of crop production.

(7) To correlate and organize educational programs through cooperating with college of agriculture, agricultural experiment stations and agricultural administrative officials.

(8) To certify seeds.

Membership: Membership of the association is comprised of corporations, copartnerships, and individuals engaged in the business of buying, selling or processing seeds. It may include others who are interested in supporting the work, such as banks, other public and private organizations concerning with the improvement of welfare of the farmers. Seed growers should always be a member of the association.

Organization:

(1) Board of Directors: Seed producers are elected by members; a representative of the experiment station; and an advisory committee of representatives of the administration, seed researchers and experiment stations.

(2) Manager: A manager is hired by the board to run the daily business of the association. He must be well experienced and competent.

(3) Seed testing laboratory: A seed testing laboratory is usually established under the jurisdiction of the association.

(4) Field inspectors: Field inspectors are employed by the association to do the field inspection works and taking samples. The number of field inspectors to be employed should be decided by the actual requirement and the availability of budget fund. During the rush season, temporary field inspectors can be hired.

Financial sources: For many agricultural developing countries, government subsidy to the association is needed, especially during the initial stage of its operation. Many associations obtain their operating income by charging fees for their services. The fee schedule includes the following:

(1) Acreage fee: It varies with the crops, the extent of the certification program, and the amount of funds required to provide the certification services.

(2) Membership fee.

(3) Sales fee: Producers of certified seed will contribute a certain percentage (In the United States, about 2.5%) to the association at the end of the sales season of their gross seed sales (seeds sold for planting purposes).

(4) Cost of tags and seals: Fixed prices for certification tag (2¢ each in the United States), analysis tag (1.5¢ each in the United States), or minimum charge on tag orders (1$ in the United States). In cases where special inspection services are required, additional charges may be made to cover the cost of such inspections.

(5) Seed laboratory services: Analysis of one representative sample from each variety will be made. In most cases, the association render one free service of the laboratory seed analysis. All additional samples will be charged for germination test (usually 1$) and purity test (usually 1$). Samples of uncertified seed will be tested for members of the association for a higher charges (usually $3-4 for each sample).

B. What a certifying agency must do:

1. To determine the eligibility of varieties for certification. Certification should be limited to those varieties which have shown superiority for certain characteristics under certain conditions. In most countries, before a variety is eligible for certification, it must be approved and recommended by an agricultural experiment station or by a governmental agency which is governing agricultural affairs.

Various types of crops have different requirements as to eligibility for certification. Varieties of self-pollinating crops such as rice, wheat, barley, soybean, peanut and oats are mostly pure-lines, which means that all plants within each variety are essentially alike genetically. These pure line varieties are easy to maintain, because "natural selection" within the variety does not affect the genetic composition,

whereas accidental admixture with seed of another distinguishable variety can easily be detected in the field and removed by roguing. Vegetatively-propagated crops, e.g. potatoes, sweet-potato, behave similarly to pure line varieties in this respect.

Varieties of cross-pollinating crops, e.g. corn, sorghum and many forage crops, however, are variable plant populations. All plants within the variety may be different genetically, although similar in one or more important characteristics. These heterogeneous varieties are more difficult to maintain, because roguing is ineffective in removing other varieties or off-types and undetected off-type plants cross-pollinate with plants of the variety and produce a new genetic composition resulting in a change of the variety. In such crops the number of varieties should be kept to a minimum and new varieties should be released only when they show a marked superiority over the existing varieties. Moreover, to maintain the varietal stability in cross-pollinating crops a number of measures in seed certification are necessary which can be omitted in the other categories of crops mentioned above. Generally, the reproduction habits of the crops concerned and the superiority of the varieties produced determine eligibility for certification.

2. Certifying agency should set up qualification standards for seed producers, including the consideration of general suitability of farm and equipment, ability of the grower, his integrity and any other qualifications essential to conducting a successful certified seed production program. All standards and procedures of seed certification agencies must be available in published form.

3. Supply each grower with instructions and material for making applications for field inspection.

4. Check each completed application carefully with special reference to origin of planting stock.

5. Make field inspection of all crops at proper times.

6. Take official samples from seed lots processed as for sale.

7. Make laboratory tests on official samples.

8. Issue certificates, certification tags, and seals where necessary or requested for seed lots that qualify for certification. Tags will be issued strictly according to amount of seed certified.

9. Publish directories of registered and certified seed.

10. Training of seed producers. It is of prime importance for the certifying agency to take up the responsibility of training seed producers. The success of the entire seed certification program depends upon the performances of seed producers.

C. The following are the general consideration and requirements for a seed farm:

There are many factors involved in the successful operation of a seed farm. The following are the important points to be observed for a successful seed production business:

1. Source of seed: The seed growers must obtain their seeds from reliable sources. He must obtain seed from those who can provide documentary evidence, such as a certification tag, sales record, etc. to prove its qualities. Breeder's seed should be used for the production of foundation seed, and foundation seed for production of registered seed. The classes of seed to be used for the production of certified seed may either be the foundation seed or registered seed. In case there is no such proper source of seed available, the producer of certified seed must have his source of planting stock approved in advance by the certifying agency.

2. The cropping history of the field: The land to be eligible must not have grown the same crop for a definite preceding period, unless the seed crop was of the same variety and of the same properly certified class. The tendency of the seeds to live over in the soil has a bearing. For example, land on which certified seeds of small grain are to be grown need only be out of the crop for the previous year, but a crop likely to leave hard seeds or surviving plants in the soil may have to be out of the crop for as much as four years.

3. Limited generation program: Foundation and registered seed production usually are confined to one generation each. Self-pollinated crops are usually eligible for two generations of certified seed production. These crops include rice, wheat, barley, flax, soybean and peanuts. Cross-pollinated crops, such as corn, sorghum, alfalfa, red clover, white clover, and many vegetable and forage crops are limited to one generation of certified seed production, and where warranted the registered seed class may be omitted. If registered seed of a cross-pollinated crop is lacking, foundation seed shall be used for the production of certified seed.

4. Isolation: Minimum isolation distances should be established for the crops to prevent contamination in certified seed fields by crossing. It must be enough to keep out crossing at a minimum but sufficiently realistic to permit the efficient production of certified seed. It is appropriate to have the minimum isolation distances for most of the open-pollinated crops 400 meters for foundation seed, 100 meters for registered seed, and 50 meters for certified seed.

Natural barriers or border rows are used for some crops as a partial replacement for isolation distances. The number of border rows is determined by the size of the field and the actual distance between it and the source of contaminating pollen. The smaller the seed field, the greater is the possibility for outcrossing. For self-pollinating crops, isolation requirements are also included in the certification standards. The required distances between varieties of the same species are usually about three meters. The primary reason for this isolation is to avoid mixtures during harvest.

5. Crop varieties: It is always advisable to limit the crop varieties for certification to those approved by a government authority and accepted by the certifying agency.

6. Number of varieties: It is desirable to limit only one variety of the same crop may be grown for seed production on a farm to avoid mixing of seeds of different varieties.

7. Grower's responsibility: The various inspections, tests and checks minimize the opportunity for carelessness and deception. However, the production and distribution of certified seed depends on the integrity of the grower or distributor. The certifying agency should have the right to act on any case where the grower knowingly or intentionally violates rules of seed certification established by the agency. The suspension of the grower from membership in the Association or the right to refuse field inspection if the applicant's reputation is unsatisfactory are all effective measures to deal with the situation.

8. Record of purity: The certifying agency should keep complete record of the growers performances, the results of both field inspection and laboratory testing of their seeds should be recorded for future reference.

V. SEED CERTIFICATION PROCEDURE:

Participation in the certification of seed usually is open to all growers. The process of seed certification must be a continuous one:

A. Application for certification with the certifying agency. (usually the application is filed with one certification tag of the seeds used in planting the crop together with the purchase invoice showing the quantity, quality and source of seed planted).

B. Checking by the certifying agency of (1) the eligibility for the production of certified seeds by the applicants; (2) whether the variety of the crop is acceptable for certification.

C. Field inspection of the applied farms (already approved) by the inspectors of the certifying agency prior to harvest for varietal purity, proper isolation, and freedom from harmful weeds. The farmer must rogue varietal mixtures and remove the weeds before inspection.

D. The seed certifying agency is notified by the farmer that the seed has been processed and bagged; the certifying agency samples each lot by sending an official inspector to take official samples of the seed lot and submit it to the state seed testing laboratory.

E. The seed samples are analysed by the State Seed Testing Laboratory. If the results of analysis are within the standards of the seed certifying agency, his seeds are certified, and he can order tags and seals from the certifying agency.

The following diagram shows the steps in a seed certification program:

A Seed Certification Program

Application for certification	Seed growers who want to produce certain kind of seeds must apply for certification.
Checked by the certifying agency for eligibility	The certifying agency may or may not grant permission to his application for certification based on various conditions and regulated standards.
Field inspection	The inspector will look for the following: Seed source; field management; isolation; contaminating crops; varieties and objectionable weeds; seed cleaning and processing equipments; seed storage facilities.
Sampling	Take samples by an inspector and send it to the seed testing laboratory.

Seed laboratory testing	Analysis of seed qualities, such as: moisture content; purity; germinability; seedborne diseases; weight per 1000 seeds; etc.
Certification tags and seals	Contains the following information: the class of seed; name of the variety; percentages of purity and germination. Seals are affixed to insure the seed is that originally certified (the container cannot be opened without breaking the seal).

VI. FIELD INSPECTION:

Field inspection must be made by the inspector of the seed certifying agency. He must be a trained and experienced field man and is very familiar with the varietal characteristics of the various kinds of crops, farming schedule, and general conditions of villages and farmers.

A. Time to make inspection: Usually during the stages of blooming and before harvest.

1. Small grains - shortly after fully headed and before harvest.

2. Beans - after pod formation and before harvest.

3. Vegetables - twice (flowering and when mature).

4. Forages - any time after establishment.

B. Method of Making Inspection:

1. Field inspection should be made in such a manner as to determine the condition of the crop and what impurities exist in the field. This can be accomplished only by walking into or across the field in such a manner as to see all parts of the field.

2. To estimate or measure the isolation condition of the seed farm.

3. To assess and determine the disease conditions of the seed farm.

4. To look carefully about the general crop and cultivation conditions of farm.

5. To inspect the seed storage, processing equipments and bags during the field inspection trip before passing the seed field.

Seeds must be stored in dry, well-ventilated or controlled, weather-proof buildings. If seeds are stored in bulk, they must be separated from any other seed of another quality or variety in such a manner that there will be no chance of mixture. Identity of individual lots of seed as to crop, variety and lot number must be maintained at all times. In order to achieve above-mentioned conditions, the inspector should see to it that the seed grower possesses adequate seed storage facilities.

6. The amount of time spent in inspecting a field will depend on acreage involved, crop inspected, the conditions of the farm and problems requiring close scrutiny.

C. Specific information required on inspection report:

1. Give the name and detailed address of the applicant. In case of contracted farms, record the names of both the applicant and the contract grower.

2. List the crop, variety, areas, and estimated yield per hectare and total yield. Indicate on inspection report all conditions that might tend to lower yield or favor a heavy yield.

3. Check field isolations carefully, which must correspond to the standards. Under no circumstances should fields be passed until proper isolation is provided.

4. Determine the previous crop on seed fields. This factor is of extreme importance for maintenance of varietal purity. Consult the manual for standards on previous cropping. There can be no deviation from the requirements as outlined in the manual.

5. The results of roguing and spraying should be self-evident. Question the grower on the use of these practices.

6. Factors on vigor, uniformity and lodging constitute a more-or-less general appraisal of the field. Estimate the reduction in yield due to lodging.

7. Make a careful check of the field for other crops. Inseparable crop mixtures constitutes a cause for rejection of the field. Separable other crops should also be considered and if excessive, the field must be ruled out. The factor of other variety must also be inspected. Any doubtful plants should be collected (few specimens are enough) and send in for identification.

8. The problem of seed processing and storage facilities should also be inspected.

D. The responsibility of the field inspector:

The field inspector has the sole responsibility of determining whether the crop qualifies, passes conditionally, or is rejected for certification.

VII. SAMPLING:

Seeds are laboratorily analysed in small quantity. No matter how accurately the technical work is done, the results can only show the quality of the sample submitted for analysis; consequently, every effort should be made to ensure that the sample sent to the analyst does, in fact, accurately represent the composition of the lot of seed in question. To obtain uniform and accurate results in seed testing it is essential that the sample be taken with care and in accordance with the methods set forth in the rules.

A. Sampling Instruments:

Seeds in bags: The most commonly used instrument is known as a sleeve-type trier which consists of a hollow brass tube inside a closely fitting outer shell or sleeve. The tube and sleeve have open slots in their walls so that when the tube is turned until the slots in the tube and sleeve are in line, seeds can flow into the cavity of the tube, and when the tube is given a half turn the openings are closed.

Seed in bulk: In sampling seeds in bulk, a much larger seed sampler of the same design is used. The length of the sampler ranges up to 63 inches and 11/2 inches in diameter with 6 or 9 slots.

6-, 9- or 12-inch thief-type trier should not be used because its construction and size do not permit sampling in accordance with the rules.

B. Who takes the sample: Usually the field inspector is the man to take the samples.

C. General procedure:

1. In order the secure an representative sample, equal portions shall be taken from evenly distributed parts of the quantity of seed to be sampled. Access shall be had to all parts of that quantity.

2. For free-flowing seed in bags a probe or trier long enough to sample all portions of the bag shall be used.

3. Nonfree-flowing seed, difficult to sample with a probe or trier, shall be sampled by thrusting the hand into the bulk and withdrawing representative portions. Great care should be taken to keep the fingers tightly closed about the seed so none may escape.

The term "Lot" is used to represent any quantity of seed up to a maximum of 20,000 kilograms (44,400 lbs.) for seed the size of wheat or larger; and 10,000 kilograms (22,200 lbs.) for seeds smaller than wheat; provided that each quantity represented to be a lot should be of reasonable uniform quality, and identified by a single lot designation.

Stocks of seed in excess of 20,000 or 10,000 kilograms, as specified above, should be subdivided into lots no larger than 20,000 or 10,000 kilograms and each identified by a separate lot designation.

4. The sampler must first determine that all seed bags being sampled are identified as belonging to a single lot, either by a label or a stencil mark on the bag. He must sample the prescribed number of bags for the size of lot at hand. If, in sampling a large lot, more seed is obtained than is feasible to forward to a laboratory, care must be exercised in reducing the quantity for shipment. As mechanical divider is usually not available, the sample reduction might best be done by placing the entire quantity on a sheet of paper or canvas, thoroughly mixing the seed by hand and halving the sample until the desired quantity is obtained.

It is essential that the inspector keeps accurate records concerning the history and manner of sampling each lot of seed forwarded for official tests. Each sample should be clearly marked so as to be easily identified. The sample envelope should be sealed to prevent any contamination and if forwarded by mail the samples should be packaged to arrive in an undamaged condition.

5. General Rules:

The following are general rules of sampling:

(1) Seed in bulk lots (in bins, cars, or other similar containers) should be sampled in at least 10 locations that will adequately represent the quantity being sampled.

(2) Seeds in bags:

a) When more than one core is drawn from a bag, follow diagonal paths through the seed bag to an opposite corner. When more than one handful is taken from a bag, take them from well-separated points.

b) In seed lots consisting of 1 to 5 bags, sample each bag. When the size of the lot is 6 to 30 bags inclusive, sample at least every third bag, but never fewer than 5 bags. When the lot consists of 31 bags or more, sample at least every fifth bag, but never less than 10 bags.

c) When sampling either bulk lots, or streams of seed during processing operation, a sample of at least 2 kilograms shall be taken.

d) If the sleeve-type probe is employed, seed bags should be in a horizontal position to insure that as the tube of the trier is opened, seed will drop in along the entire length of the bag. The probe should be inserted with the slots facing downward so that as it is inverted, or placed upright for collecting the sample any seeds "dragged along" by the cross ribs will be dislodged and will not be added to the portion drawn.

e) Each probeful of seed from each bag sampled should be examined before adding it to the composite sample in order to determine that the seed being sampled is uniform in quantity. Uniformity of color and general weed seed content should be noted and any probefuls deviating from previously drawn portions should not be added to the composite sample. The bags of seed in question should be appropriately identified, set aside, and cannot be considered a part of the lot being sampled.

(3) Chaffy Seeds: Certain chaffy grass seeds and non-free flowing seeds which may not be easily sampled with a probe can be sampled by hand. Hand sampling necessitates opening the seed bag, thrusting the hand to different parts of the bag, and removing small portions of seed from the bottom, center and top.

(4) The following points should always be observed and kept in mind while taking samples:

a) Do not accept samples drawn by the applicant.

b) Do not sample uncleaned seed.

c) While sampling (use a probe), make sure the problem of uniformity among different bags of the same lot is attended.

d) Samples of doubtful qualities should be kept separately and might be regarded as different samples even it is drawn from the same lot of seed.

e) Report the following in every case:

i. Variety, kind, growers name, address, contract grower, if any.

ii. Lot number.

iii. Time harvested.

iv. Number of bags or kilograms in each lot.

v. The seeds are bagged or in bulk.

vi. Number of tags, or seals, or analysis tags desired.

vii. New bags or old bags are used.

f) Samples should be bagged properly and mailed or delivered to the seed testing laboratory as soon as possible.

g) The sampler should keep complete records of daily works of sampling for future reference.

h) Bagged seeds must be stacked in such a manner that the inspector can sample most of the bags and an accurate counting of bags can be made.

D. Minimum Weights of Samples To Be Submitted For Analysis:

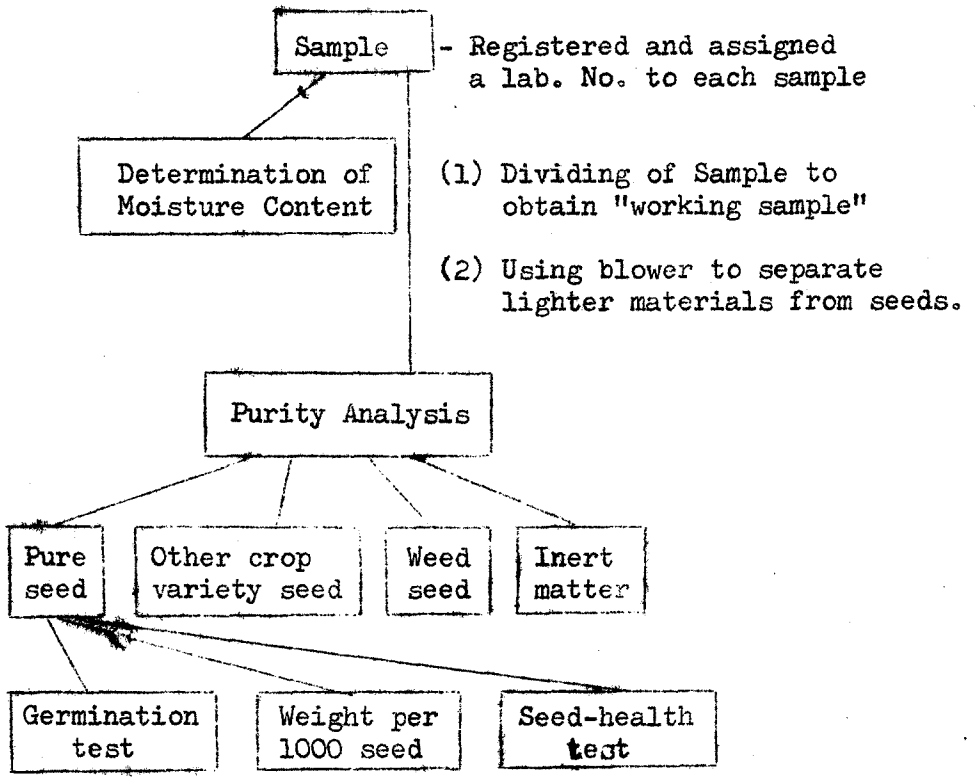
The minimum size of sample for each kind of seed to be submitted to the laboratory for all tests and examinations, will be found in the second column of Table 1 attached. A sample for a moisture test shall consist of at least 100 grams. For determination of provenance or origin the sample size shall be at least five times the quantities indicated in the second column of Table 1, except that no sample needs be larger than 1000 grams.

In case the sample submitted is smaller than specified, the sender should be notified accordingly and analysis withheld until sufficient seed is received; provided that, in the case of very expensive seed, the analysis may be completed as far as possible and the following statement inserted on the report or certificate: "This sample weighed only ..... grams and it is therefore not in accordance with the size of sample specified in the International Rules for Seed Testing."

If the sample was taken by an inspector, he should make every effort to obtain samples of at least the minimum quantities set forth in the rules. To those kinds of seed of high monetary values, at least the size stated in the rules should be taken in order to provide adequate seed for standard tests, and retests if necessary.

VIII. LABORATORY ANALYSIS OF SEED:

The following is the diagram showing the procedure of laboratory analysis of seed sample:



A. The Working Sample: It is the reduced sample for determination of either purity, germination, noxious weed seed, genuineness of variety, and all other determinations. Great care should be taken to ensure that the working sample represented the material sent in for analysis.

The minimum quantities to be used for the purity analysis and noxious weed seed examination are given in Table I. In case the kind of seed is not listed, the weight of the working sample may

be determined from Table 1 by a kind of seed that is similar in size and weight and which would provide approximately 2,500 seeds in the purity working sample.

In obtaining the working sample, the following methods shall be used:

1. By means of an efficient mechanical divider: This method is preferred for free-flowing seeds. After mixing, the sample should be repeatedly divided until a portion is obtained of approximately (but not less than) the size required for the working sample.

2. By means of the random cups method: A tray of convenient size is used. On it are placed 6 - 8 cups or small containers of equal size, scattered at random over the surface. The seed is shaken gently from a seed pan over the surface of the tray, following a regular pattern to ensure even distribution first working in one direction and then in a direction at right angle to the first. The seed caught in the small containers is used as the working sample, or this may be further reduced, if necessary, in a similar manner after mixing.

3. By means of the modified halving method: This procedure is similar to that given in (2), but instead of random cups a modified tray is used, divided into an even number of square compartments, every alternate one of which has no bottom. When the seed is shaken over the tray and the tray lifted, half the sample remains on the pan placed beneath the tray. In this way, the sample is repeatedly divided in half until a sample of the desired size is obtained.

4. By mixing by hand: The sample should be well mixed and spread out in a layer of uniform thickness on a flat tray or mixing basin. The seed, after being spread out, must not be shaken before being sampled; should this happen, the blending and spreading must be repeated. Small portions of the seeds should then be taken with a special spoon from a number of different places on the tray, until the proper quantity has been secured. In no case should the number of spoon samples be less than five.

B. The Purity Analysis:

The object of the purity analysis is to determine: a) the composition of the sample being tested and by inference the composition of the seed lot, and b) the identity of the various kinds of seeds and inert particles constituting the sample. In accomplishing this objective, the sample is separated into the following four

component parts: 1) kind, variety, or type to be considered pure seed. 2) other crop seed, 3) weed seed, and 4) inert matter.

The purity analysis of seed is a meticulous, painstaking work, requiring constant use of eyes and concentrated attention. To many people, it is monotonous and without excitement. The seed analysts usually spent whole day sitting and analysing one by one of individual seeds trying to identify and to distinguish the various components constituting a seed sample. In order to do a good job of a seed analyst, one should have the basic knowledge of seed taxonomy, seed morphology and agronomic phase of crop science. He should have the full knowledge of the varietal characteristics, local farming practices and the related matters.

In order to make the work of seed analysis more efficient and to avoid serious eyestrain, the purity analysis room of the seed testing laboratory should be large, and bright by sunlight. It is believed that daylight causes less eye strain and fatigue than any other light. If artificial light is used the analysts should have individual and adjustable flourescent lamps of the daylight type.

1. Definitions

(1) Pure Seed: The pure seed is the seed of all varieties of each kind under consideration as claimed by the sender or detected by the laboratory test. It may be shriveled, cracked, or otherwise injured, and pieces of seeds that are larger than one-half of the original size whether broken, insect-damaged, or diseased, except seeds of legumes and crucifers with the seed coat entirely removed, which shall be classified as inert matter.

In addition to all mature, undamaged seed of the kind or variety in the sample, the following particles are included as pure seed:

a) Undersized, shriveled, or immature seeds, provided they can be definitely identified as the kind under consideration; grass florets with an obvious caryopsis containing endosperm.

b) Pieces of seed resulting from breakage, that are more than one-half their original size. Provided that seeds of the Leguminosae, Cruciferae, and Coniferae with the seed coats entirely removed shall be regarded as inert matter.

c) "Seeds" (botanically, fruits and fruit-like structures), regardless of whether they contain a true seed, unless it is readily apparent by visual examination that no true seed is present; included in this classification are Beta, Tetragonia and one-seeded fruits such as Valerianella, Cichorium, Lactuca, Helianthus, and Fagopyrum.

d) Diseased seeds: Provided that seeds which have been altered by fungi to form sclerotia or smut balls resulting from nematode infestation shall be regarded as inert matter.

e) Free caryopsis of cereals and grasses removed from the glumes.

f) Four-fifths of the weight of the multiple floret of Dactylis glomerata which contain at least one caryopsis shall be regarded as pure seed.

(2) Other Crop Seed: Other crop seed shall include seeds of plants grown as crops. With respect to the classification of immature, damaged, diseased, and empty seeds, the distinguishing characteristics set out for pure seed shall also be applicable to other crop seed.

(3) Weed Seed: Seeds, bulblets or tubers of plants recognized as weeds by laws, official regulations, or by general usage shall be considered weed seeds. Universally accepted distinctions between weed seeds and crop seeds are not possible since in certain instances a given species may be regarded as a harmful weed in one place and as a useful crop in another. Therefore, seeds of plants which are generally regarded as a crop plant but in certain countries as weeds should be reported separately, as a percentage, on the Analysis Certificate if requested by the sender. All seeds and seed-like structures of weed plants, including noxious weed seeds, except certain undeveloped or badly injured weed seeds as described under "inert matter" below, shall be considered as weed seeds.

(4) Inert Matter: Inert matter shall include seed-like structures from both crop and weed plants and other matter not seeds as follows:

a) Seed-like structures from crop plants:

i. Pieces of broken or damaged seeds one-half the original size or less;

ii. Seeds of legumes and crucifers with the seed coats entirely removed;

iii. Empty glumes and unattached sterile florets of grasses;

iv. Attached sterile florets of grasses, which must be removed from the fertile florets except in Chloris gayana, Arrhenatherum elatius, Dactylis glomerata, and species of Poa. In the case of Dactylis the weight of the multiple florets which contain at least one caryopsis shall be determined, four-fifths of the weight added to the pure seed, and one-fifth to the inert matter.

v. Broken and unattached wings of tree seeds: However, wings attached to the seed units shall not be removed as inert matter. Attached wings of tree species which must removed from the seeds except in Acer, Betula, Catalpa, Chamaecyparis, Cupressus, Fraxinus, Liquidambar, Liriddendron, Platanus, Thuja, and Ulmus.

b) Seed-like structures from weed plants: All badly injured, undeveloped or empty structures which resemble seeds but which by visual examination (including the use of reflected light) can be definitely demonstrated as having no embryo, except in the case of vegetative reproductive structures. Included as inert matter are structures from weed plants as follows:

i. Seeds of grasses with over one-half the embryo removed;

ii. "Seeds" of Cuscuta species which are fragile or ashen gray to creamy white in color;

iii. Glumes and florets of grasses in which the caryopsis has not developed;

iv. Seeds of Leguminosae and species of Brassica with the seed coats entirely removed;

v. Seeds of Ambrosia with the involucre and pericarp absent;

vi. Black "seeds" (without any brown color) of Plantago lanceolata, whether shrivelled or not.

c) Other matter: Soil, sand, stone, chaff, stems, leaves, nematode galls, cone scales, pieces of bark, flowers, fungus bodies (such as ergot, other sclerotia, and smut balls), and all other matter not seeds. Sclerotia, smut balls, and galls shall be shown as such under the heading "Inert matter" on the Analysis Certificate.

2. The Working Procedure of the Purity Analysis:

(1) Use one of the methods as described above to divide the sample to obtain a working sample. No addition or reduction by hand to the sample obtained is allowed. The weight of the working sample for any specific kinds of crops is regulated as listed in Table 1. The working sample shall then be weighed in grams to four significant figures.

(2) The purity analysis shall be made in duplicate by testing two subsamples drawn independently from the bulk sample. Each such subsample shall be at least one-half the quantities listed in Table 1. Owing to sampling variation is to be expected that there will be differences in the results of duplicate analyses. Tables 3, 4, 5 and 6 shall be used in determining allowable latitudes of variation between duplicate samples. (note: This is somewhat time consuming and an experienced analyst will find it more satisfactory to test the entire working sample as one, in the same manner as is done according to the Rules of the AOSA when comparative tests are made with another laboratory the ISTA rules should always be followed.)

(3) A blower (South Dakota Blower) can be used to separate the lighter portion of the sample.

(4) A specially designed purity working table is used for the purity analysis of seeds. The working sample is separated carefully into four portions; namely: pure seeds, other crop seeds, weed seeds and inert matter. Three small petri dishes are placed on the analysis table to keep the three portions of the sample. The largest portion of the sample, viz, pure seeds is placed in the drawer of the specially designed working table.

The first step in making a purity analysis is to examine the sample of seed submitted for test to determine whether it is correctly named.

Hand lens should be used in examining small legumes and grass seeds. A reading glass may be substituted for the hand lens in examining some samples of large seeds. A stereoscopic microscope is necessary for examination of seeds of questionable identity or classification.

In making purity analysis of seeds, the analysts must be familiar with the structures constituting the seed unit in each group in order to make accurate identifications and distinctions between pure seed and inert matter.

(5) After the working sample is all separated into the four portions, they are weighed separately in grams to the same number of decimal places as the working sample.

(6) Calculation of percent of component parts in the sample

The percentage by weight of each component (based on the sum of the weights of the component parts and not on the original weight) shall be determined. The sum of the weights of the component parts shall be compared with the original weight of the working sample as a check against loss of material or other error.

a) When the minimum working sample is 500 grams, the pure seed need not be weighed. In this case, the inert matter, other crop seeds, and weed seeds shall be weighed and the total of their weights is subtracted from the weight of the working sample to obtain the weight of the pure seed. There should be not more than 1 percent variation between the weight of the original sample and the total weight of the four components. If the gain or loss is greater than this amount, another test should be made.

b) Components which are too small to be assessed by weight at the fourth significant figure shall be reported as a trace.

c) When any particular kind of inert matter or species of weed seed totals more than approximately one percent, the percentage of such material should be recorded on the Analysis Certificate. The

name and percentage of each kind of crop seed present to the extent of 5 percent or more shall be reported on the Analysis Certificate.

3. Separation of similar kinds or varieties

When the working sample consists of two or more similar kinds or varieties which would be difficult to separate in the entire sample, it is permissible to weigh the similar kinds or varieties together as one component and make the separation on a reduced portion of the sample as follows:

At least 400 seeds, preferably 800 to 1,000 shall be taken indiscriminately from the pure seed component and the separation made on this portion. The proportion of each kind present shall then be determined by weight (except Agrostis, which is to be determined by count) and from this the percentage in the entire sample shall be calculated.

The following are examples of the problems commonly encountered during purity analysis of the seeds:

(1) Gramineae (Grass family) -- Rice, wheat, corn, sorghum, barley, etc.

In this family of seeds, the inert matter consists chiefly of the following: empty florets of both weed and crop species of containing only anthers or undeveloped ovareis; broken pieces of pure seeds and other crop seeds which have been reduced to one-half or less than their original size; pieces of sticks and stems, chaff, and dirt; empty fruits or seeds of weeds; smut, ergot and nematode galls.

(2) Leguminosae (Pea family) -- Soybean, peanuts, peas, etc.

Inert matter in legume and other seeds consists chiefly of: pieces of pure seed and other crop seed which have been reduced to one-half or less of their original size; seeds with the seed coats entirely removed; pieces of stalks and stems, chaff, and dirt;

empty fruits or seeds of weeds; in case that there are such small portions of the coats left on the seeds that it is impossible to identify them as pure or foreign seed. Such structures are included with the inert matter.

If the broken fragment contains a portion of the seed coat, one cotyledon and the embryo, judgment will have to be exercised to determine whether it is more than half its original size and should be regarded as a seed.

The problem of insect-damaged or infested seeds are often very difficult to classify. It is not ruled in the definition of pure seed. The analysts should examine carefully to determine whether the insect-damaged or infested seeds have lost their ability to germinate. A hole caused by insects in the portion of cotyledons far from the radicle does not render the seed lost its ability to germinate though it may weaken it.

(3) Cruciferae (Mustard family) -- Rape, cauliflower, kale, etc.

The problems encountered in the seeds of this family are more or less similar to those of Leguminosae. But the principal problem in this family is identification of the seed. All samples of Brassica should be checked to see that they are correctly named. Keys, descriptions, and illustrations are valuable aids in identifying seeds of Brassica but skill in their identification can be developed only through comparisons with actual samples and growing tests.

(4) Malvaceae (Mallow family) -- Cotton, kenaf, etc.

Cotton seed with lint on it should be carefully examined for weed seeds which cling to the lint.

4. Identification of Varieties:

The identification of varieties or the determination of the genuineness of type and variety should be carried out for all samples which have been named by the sender, as regulated by the International Rules, provided the determination can be made by comparatively simple methods using the botanic characters of the seed. Where type and variety are difficult to identify from the seed characteristics, or if special laboratory or field plot tests are required, determinations shall only be made on special request or when they are required as part of certain regulations.

The botanical name of the species should be stated on the certificate of analysis as well as the common name. The term "kind" usually means species and may in certain circumstances mean genus but in the International Rules, never means cultivated variety. Therefore, all cultivated varieties of the kind under consideration must be included in the pure seed even though they differ from the variety stated by sender. If there is more than one variety present, and they can easily be distinguished in the course of a routine purity test, then a determination of variety is obligatory.

The identification of varieties of seeds is usually done by careful examination in the laboratory of all the morphological characters of the seeds. Seeds of different species are usually different in shape, size, color and surface structure. But there are many exceptions. Difficulties are often encountered in laboratory trying to distinguish seeds of different species and varieties just based on their morphological characters (such as seeds of Glycine, Brassica, Lolium, Oryzae sativa, and many others).

It is an important object of the seed testing stations to be able to determine whether a certain sample is the variety it is said to be. When direct examination of seeds failed to distinguish its varieties, many other methods are now employed to supplement it.

(1) Field Plot Test:

It is the most obvious that the direct sowing of the seeds in field and observation of the emerging plants is able to distinguish even closely related varieties by taking all morphological differences at all stages of development as well as physiological differences as to rhythm of development, flowering season, etc.,

into consideration. Field plot test is usually done by planting side by side the seeds in question and the standard seed sample of a similar variety. Whenever possible, field plot tests should be made in the country in which the variety originated, since the variations in the morphology and genetic nature as well as the eventual smaller, permissible changes which have arisen by the production of new elites by the breeders, are best known in the country of origin.

Field plot tests may be carried out in countries other than the country of origin only on condition that the morphological characters of the variety are well known. An institute which has received a sample for field plot testing shall arrange for the sample to be sown during the first growing season after the arrival of the sample. Growing should be carried out under such conditions as to ensure that the plants develop normally. This requires: a) growing within an area where it is known that the characteristics of the variety appear with sufficient clearness; b) suitable soil and favorable conditions in general; c) growing during suitable season and d) suitable control of insect pests and attacks of diseases not seedborne. Greenhouse with temperature and irrigation facility is preferred in which optimum growing conditions for the particular kind/variety are provided. Many kinds of crops do require particular growing conditions in order to show its varietal characters. The samples are sown in at least 2 replications, which, if it is considered necessary to ensure more exact results, are sown in different fields. Samples delivered with identical varietal names are sown in succession with plots from standard samples at suitable intervals for comparison.

(2) Color of hypocotyl:

This method was used to distinguish the varieties of Beta genus. The method was originally used to establish the color of hypocotyl in the various Beta varieties, and it is now also used as an aid to examine the genuineness of varieties of white beets by determining the proportion between pink and greenish white hypocotyls, this proportion being almost constant for the various varieties of the Beta group.

In most cases this can be done by germinating the seeds at a given temperature and under light on the Jacobsen apparatus on filter paper covered with a glass or plastic bell jar.

(3) The Fluorescence Method:

It is most extensively used for distinction between Lolium perenne L. and L. multiflorum Lam. The seeds proper do not show flusrescence but the traces left by the roots of the seedlings grown on filter paper. This reaction was first pointed out by Gentner. It was originally assumed that there was a means by which they could be clearly and reliably distinguished, as all seeds of L. multiflorum would show fluorescence, while no seeds of L. perenne possessed this quality. However, later examinations have shown that it is not quite so. Many varieties of L. perenne contain seeds, the root traces of which are fluorescent. So a complete separation of the two species is not possible by this method. But the proportion between fluorescent and non-fluorescent seedlings of L. perenne is applicable as an aid to separate varieties of this species, this proportion being to some extent characteristic of the various varieties.

Fluorescence test is also used for separation of oats with white and yellow lemma, the former being fluorescent as shown by Hellbo.

The fluouscence method was first introduced by Gentner, which used the effect of the rediation of a particular, coloured light emanating from many substances when irradiated with ultra-violet light.

(4) Phenol method:

This method was introduced by Pilper for the separation of some varieties of wheat. When wheat seeds are soaked in a phenol solution for disinfection, the grains of various varieties showed different reactions, some assuming a dark color, while those of others remained uncolored.

This method which is used in many places on wheat varieties, is also applied to certain varieties of barley.

During the process of the test, phenol affects the germination process of the seed which was started up by presoaking. In the phenol test the grains should never entirely disappear below the phenol. The reaction rate is a very characteristic property of the variety. Attention should be paid to the intensity of the color and in particular to the time taken for the coloring to arise. The rate can be somewhat influenced by the strength of concentration of the phenol solution.

Procedure of the phenol test of wheat seeds:

2 x 100 kernels are counted, and soaked for 24 hours in distilled water. After removing the water, grains are placed in petridishes on white filter paper moistened with 3 cm^3 of one percent solution of phenol. Wheat varieties can, as it is known, be grouped according to the color reaction of kernels after 4 hours, it is good to follow the changing of color even earlier, and to verify the result after 24 hours.

(5) Seedling Test:

Many varietal characteristics are exhibited distinctly at a juvenile stage of the leaf. As the leaf ages the characters are coarser and less clearly defined, so that the distinction is less sharp. The following are various characters may be distinguished in the first time leaf that immerges after the cotyledons.

(1) Shape: The shape is important and the length/width ratio.

(2) Veins: The veins may be distinct or less distinct at the top or underside, and may be colored or may be not colored with authocyane.

(3) Blade: The blade may have indentations of varying depth, may be covered with a waxy layer. Between the veins the leaf may be glossy or sinuate. The blade may be covered with hairs, slightly hairy, or hairless. These hairs may also occur only along the leaf margin or on the top. The hairs may be verticle or more inclined to the margin. There are also "ordinary" hairs, recovered hairs, glandular hairs, etc.

(4) Leaf margin: The leaf margin may be entire or serrated. The teeth may be scattered or dense. The direction of the teeth in relation to the leaf margin may also vary.

(5) Shape of the apex: May be pointed, round, incised.

(6) Color: The color of the leaf is not always a reliable feature. It can only be relied upon when the leaf is examined at the proper time and after the plants have been cultivated under optimum conditions.

The conditions of seedling test:

Temperature and lighting should be maintained at optional level which are adapted to each variety. Generally speaking, a slightly too low temperature is less harmful than one which is slightly too high. The plantlets should be firm and not etiolated. The moisture supply should be regulated for each species according to the temperature.

The plantlets may be grown in containers made of various materials. The substrata in which the plants are grown must be selected carefully. The composition of the substrate to be used for this purpose must be standardized in order to obtain reproducible results.

Such a standardized soil should contain as little as possible any organisms inducing diseases. Both greenhouse and incubator can be used for placement of the containers. During the winter season considerable difficulties may occur in greenhouse with regard to the amount of light in relation to the temperature, and in the summer the excessive temperature will usually prevent many greenhouse from being used. In either case the plants obtained might be abnormal.

The following are few examples of the methods used for varietal identification:

Wheat: The methods used by Finland State Seed Testing Station for identification of wheat varieties are as follows:

1. Examination of characters of dry grains.

2. Treatment of grains with phenol.

3. Examination of seedlings grown in laboratory (or in greenhouse)

4. Examination of plants in the field plots.

1. Examination of characters of dry grains.

(1) The seed sample to be analyzed is at first looked over as a whole to see if the sample is, at least for the most part, of the variety stated by the sender, or if it is perhaps entirely of another variety.

(2) For more thorough investigation at least 2 x 200 grains are counted without selection. The grains are then examined one by one by the eye or by means of a lens (c.3x) or a microscope (c.30x)

(3) Other characters, such as color and the size of the grain, size of embryo, form of the grain, hairiness and length of the hairs at the apex of grain.

2. Treatment of grains with phenol.

3. Examination of seedlings grown in laboratory

Most varieties of wheat have green coleoptiles but some have violet ones. There can be varietal differences even in the intensity and shade of color, and also other differences in young plants, e.g. on auricles.

At least 200 seeds are set up for germination on white filter paper in dishes covered with a glass or plastic in room temperature (18 - 20°C), usually in artificial light; the substratum is kept suitably moist. Seedlings can as well be grown in sand or soil, the essential thing being that the same way is always used because of the comparison of varieties.

4. Examination of plants in the field plots

Though this is the most sure method, it has, however, the disadvantage that it takes so much time, and the results are not available until the seed has been sold and sown. Thus it can be used only as a past control.

Procedures: The grains of admixtures are to be separated from a definite quantity of seed, and both groups are to be sown separately but in the same plot for a more exact verification. Examinations of varieties in the field are begun at sprouting stage. The color of sprouts will serve as a good reference to the determination of genuineness of varieties. Observations are written down into the field note book for later examination. Visual observations are made several times during the whole period of growth, and especially at the heading and ripening time.

Possible admixtures are detected at the stage of development most suitable for investigation of the character in question. If e.g. there seems to be as an admixture variety with auricles of different colour and hairiness from the variety stated by the sender, then the auricles ought to be examined when the leaves are still green; at the stage of ripening the color and hairs are obscure.

It is as well to examine the length of marginal hairs on the internodes of the rachis in the green stages. The length of the hairs may show distinct differences between two varieties quite similar in other respects.

Hairiness on the node of the culm and on the part of the culm just above the node differs from variety to variety; even the thickness of hairiness can be different in various varieties. This character too can be seen best before ripening. The same node, preferably the uppermost, ought always to be examined.

Even the cross-section of the culm may be different in various varieties; most varieties have a hollow culm, some more or less solid. As it is known, the form of ears, the length of awns, the color of glumes, the hairiness of glumes and the glume point can be different in various varieties. The color of glumes must be examined just at the ripening time when differences of color are at the clearest.

Possible other varieties in the bulk are searched for as the examiner goes on the path between the field plots, and looks at only one or two rows at a time. Plants of other varieties are taken away by the roots, and their number is put down in the field note book. The test plot should be long and narrow. So it is easy to see every plant in every row.

A further inspection is carried out somedays later because some characters of varieties can be seen more distinctly at that later moment.

This kind of inspection, merely by sight, is not sufficient when the bulk of the sample and the admixture are so similar that they can be distinguished only on the ground of some characters invisible to the naked eye, e.g. different length of hairs on the rachis. In those cases, an adequate number of plants (200 -500) is pulled up and examined by means of a lens.

Oats: A. Identification of cultivar based on Kernal characteristics

The identification by seed characteristics is of first consideration.

1. Lemma color - A major character in classifying oats which consists of black, red, yellow, gray and white. Nilsson-Ehle reported the consistency of color inheritance in oat grains, though he noted a slight variation in colors under change of environment.

2. Kernel width, length, form and weight: Pointed, short, barley-like, and full or plump.

3. Basilar connection of the grains

The manner of separation of the first floret of the spikelet from it basilar connection, or the pedicel, and the second floret from the first or primary floret is a most valuable character for classification.

4. Hairiness of the grain:

In cultivated oats the lemmas are glabrous, except for a few varieties that produce a few hairs over the lateral and dorsal surfaces of the lemma.

Basal hairs, hairs of the rachilla and the awns are often destroyed by threshing, and these characters therefore are treated in connection with field plot methods.

B. The fluorescence Test:

A lamp transmitting radiations between 3,000 and 4,000 A.U. with a max. radiation between 3,600 and 3,700 A.U. and a trace of visible light is required as a source of ultra-violet light.

Both lemma and palea show a specific fluorescence or non-fluorescence reaction, depending on the variety under investigation. The caryopsis, however, show the same fluorescence reaction in all varieties and can not be counted in purity analysis.

In the Scandinavian countries, Canada and some states in the U.S. the fluorescence test has been used as a routine laboratory test for the detection of admixtures in oat seed samples.

The common procedure is to inspect the sample under ultra-violet light, remove the off-type kernels, and make the final examination of the sample under ordinary light by seed characteristics or in field plots. A suitable amount of yellow or white oats for investigation under ultra-violet light is 500 gm.

C. Biochemical Test

Chmelar described methods for accelerating the phenol test, and also that by soaking oat kernels in 10% HCl for 30 minutes, then dry for 24 hours, the white grained oats become light brown and the yellow grains assume an intense yellow color.

D. Greenhouse methods

Rasmussen raised the plants in glazed clay pots, containing guartz sand of pH 8.4. No nutrients were added except a small quantity of $MnSO_4$ to prevent gray-speck disease. The observation is made during a period of 5 - 6 weeks after planting. According to Rasmussen the most valuable characters were:

1. On the blades of the leaves.

   a) The hairiness of the leaf margin.

   b) The hairiness of the upper and lower surface of leaves.

   c) The number and size of teeth on the margins of the leaves.

2. On the sheaths

   a) Hairiness of the sheaths.

   b) Hairiness of the sheaths just below the leaf blade.

   c) Anthocyanin color of the sheaths.

3. At the nodes

   a) Hairiness below the nodes on the stem.

   b) Hairiness just above the nodes on the sheaths.

4. Color of lemma

The characters of the resistances to certain kinds of plant pathogens are also used for trueness-to-variety tests. The application of plant pathogens in routine testing may necessitate temperature controlled greenhouse space, an easy access to reliable inocolum, and a personnel trained for work with plant pathogens.

E. Field Plot Methods

1. Juvenile plant growth:

Nearly all spring oat varieties have an erect habit of growth. The more distinct winter forms of oats show a spreading or prostrate habit of growth and the two groups, spring and winter oats may be differentiated by this character.

2. Tillering: Spring oats usually have few tillers compared to winter oats.

3. Height of plants: The character is influenced by environment but in field plots when the cultivars growside by side, the character is useful for the detection of mislabelled samples as well as for the detection of impurities.

4. Time of heading:

The character is especially useful for the detection of mixtures of early heading varieties in late heading varieties.

5. Leaf characters:

1) Characters as width, length and colour of leaves have not been useful in classification.

2) Hairiness of leaf margins and leaf bases. These characters should be examined early in the growing season since the hairs may be rubbed off by wind etc.

6. Sheath characters

Marquend considered the presence of absence of hairs on the sheaths to be valuable in classification. Rasmussen used the density of hairs on the sheaths to differentiate 14 oat varieties from a total of 46.

Stanton however, states that the most important sheath character is the presence or absence of ligules. Nearly all varieties of oats have ligules, but some varieties belonging to Avena sative subspecies orientalis, lack ligules and this is of great taxonomic value.

7. Stem characters:

1) Stem length, width and color have not been applied much in classification of oat varieties.

2) Militz applied the size of the upper node for classification.

3) Hairiness of culm internodes. Etheridge determined that the pubescence slightly above or below the nodes differed among cultivars, but he did not consider the character important in classification.

In field plot studies mostly the hairiness of the upper node has been employed in classification, whereas Rasmussen in greenhouse studies also found the hairiness of the third, fourth and fifth node to be sufficient for classification purposes.

The hairiness at the nodes ought to be observed not too long after heading since at many locations the hairs are easily rubbed off by wind.

8. Panicle characters:

Within the oat varieties there are two distinct forms of panicles:

1) Equilateral panicle. This panicle type often is subdivided into three groups, depending mostly on the angles between the branches and the rachis: a. Erect, b. Spreading, c. Drooping.

2) Unilateral panicle (side, banner or horsemane). In this type of panicle the branches and the spikelets definitely turn to one side.

Panicle form should be described and observed shortly after heading, since toward maturity most varieties may appear to have unilateral or drooping panicles.

3) Rachis

a) Place of attachment of lower whorl branches. In a number of varieties, particularly in the group with unilateral panicles the lower whorl of branches arises at a geniculate bend or secondary node in the rachis, and not at the first or lower rachis node as is common in most varieties.

b) In most varieties the rachis is more or less flexuous, but the two extremes; straight or very flexuous rachis, may be used for descriptive purposes.

4) Hairiness on the swollen bases of primary branches of oat varieties.

This character is neither conspicuous nor easy to observe. However, the character is very valuable in differentiating varieties otherwise similar in morphology, and the character has the great advantage that it safely can be employed at time of maturity, when other important characteristics are no longer useful.

In each panicle there are usually 4 - 6 whorls of branches or nodes, but the safest differences among varieties are found at the lower node.

5) Spikelet characters

a) The number of seeds per spikelet or the number of spikelets per panicle is greatly affected by environment and these characters are not too useful in classification.

b) Spikelet and floret separation is valuable for identification in field plot tests.

c) Length, width, number of veins and color of the glumes are found not of particular value for identification.

6) Awn characters

The characters have been used most extensively in the separation of species. In the wild forms of the tribe Aveneae the awns usually occur also on the second and third floret of the spikelets, whereas in most cultivated oats of Avena sativa the awn occur only on the first floret and is straight (38).

In cultivars belonging to A. byzantina, awns usually occur on the 1 and 2 floret and are usually straight. In cultivated red oats occur both twisted and non-twisted and geniculated awns.

7) Grain characters (Hairiness of grains):

(1) Basal Hairs: This character is mentioned already in Korniche & Werner (24) and it has been used in classifications by many investigators. Most investigators have applied not only the density of hairiness, but also the presence of long or short hairs. Stanton (38) proposed a rather complete scheme for description of basal hairs:

a. Numerous, long, midlong and short.
b. Several to numerous, long, midlong and short.
c. Several, long, midlong and short.
d. Few to numerous, long, midlong and short.
e. Few to several, long, midlong and short.
f. Few or absent.

The length of the basal hairs were classed as long (2,5 to 4,0 mm.), midlong (1,5 to 2,5 mm.) and short (0,5 to 1,5 mm.).

This character is very useful in field plots were the kernels can be carefully removed from the spikelet. The basal hairs are readily removed by threshing.

(2) Second Floret Rachilla Segment. Etheridge (5) considered length and hairiness of the rachilla segment worthy of use, and in some cultivars the partial envelopment of the rachilla by the lemma. Stanton (38) used the hairiness and length of rachilla in descriptions but he considered length of the rachilla to be useful only in cultivars with extremely short or long rachillas.

In field plots all these characters can be employed at the time each character is most easily observed.
Generally, characters based on hairiness of the plant, should be observed and described shortly after heading. The main shoot only (not the tillers) has been used for the description of morphological characters of the plants. Investigations for trueness-to-cultivar, thus, should be carried out by observing characters of the main shoot.

5. Seed Unit: The seed unit is the structure usually regarded as a seed in agricultural practices and in commercial channels. The seed unit may consist of one or more of the following structures:

(1) True seeds --- Legumes, Solanaceae (pepper, tomato, eggplant), Malvaceae (cotton, okra), Linaceae (flax), Cucurbitaceae (cucumber, squash, pumpkin, watermelon, cantaloupe), Cruciferae (radish, kale, cauliflower).

(2) Caryopses and florets in the grass family. In this family the pure seed unit also includes the following structures for the indicated kinds:

a) Spikelet or paired spikelets with at least one caryopsis in the blue stems and yellow indiangrass.

b) Bulblet of bulbous bluegrass (Poa bulbosa)

c) Fascicle of buffel grass (Pennisetum ciliare).

(3) Dry indehiscent fruits in the following plant families:

Budkwheat (Polygonaceae), sunflower (Compositae), gernaium (Geraniaceae), goosefoot (Chenopodiaceae).

(4) One- and two-seeded pods of small-seeded legumes, and pods of peanuts. Pods of legumes normally containing more than two seeds, when occurring incidentally in the working sample, should be hulled when marketed.

(5) Fruits or half fruits in the carrot family (Umbelliferae).

C. TESTING FOR GERMINATION

The ultimate aim of testing for germination is to gain information with respect to the field planting value of the seed and to provide results which can be used to compare the value of different seed lots. But it must not be assumed that germinability in the field can be pre-determined by a laboratory test but the relative value of a seed lot can be measured in comparison with another.

The germination test by a seed testing laboratory is to determine the maximum germinative capability of a seed lot by providing the most favorable conditions. Field conditions in one country or locality, in one season or another, can not be duplicated. The biochemical and biological changes of soil, the different structure

and texture of soil are very difficult to duplicate too. Therefore, it is necessary to establish standards and procedures which can be duplicated in different countries and in different regions of the world. The basic requirements for germination of most crop seeds are (1) water, (2) oxygen and (3) temperature. The seeds can obtain water through the agency of the substrata on which the seeds are planted. Oxygen is available from the atmosphere. Temperature conditions are regulated in the germinator in which the seed is placed. Light is not a necessity to seed germination of many seeds, but to some kinds of seeds, light is an essential factor to its germination.

In the profession of seed testing, a seed shall be considered to have germinated only when it has developed into a normal seedling. Broken seedlings and weak, malformed, and obviously abnormal seedlings shall not be considered to have germinated.

If the basic requirements for seed germination are provided, one may expect to measure the maximum viability of seed lots which in general will be greater than when planted in the field. There are many factors interfere with or prevent maximum germination. They are:

1. Non-viable embryos
2. Low vitality
3. Too much water
4. Insufficient oxygen
5. Dormancy of seed
6. Insufficient water
7. Unfavorable temperature
8. Improper handling
9. Presence of parasitic bacteria or fungi on or in the seeds. Sometimes saprophytes overrun seed lots and make an interpretation of normal and abnormal seedlings difficult.
10. Seed damaged by insects.

1. Definition:

1. Seed germination: In laboratory practice germination is defined as the emergence and development from the seed embryo of those essential structures which for the kind of seed are indicative of its ability to develop into a normal plant under favorable conditions in soil.

2. Normal seedling: Seedlings possessing those essential structures that are indicative of their ability to produce plants under favorable conditions.

3. Abnormal seedling: All seedlings that do not permit classification as normal seedlings.

4. Firm ungerminated seed: Seed, other than hard seed, which neither germinate nor decay during the prescribed test period and under the prescribed test conditions. Seeds known and recognized to contain firm seeds are Johnson grass.

5. Hard seed: Seed which remain hard at the end of the prescribed test period because they have not absorbed water due to an impermeable seedcoat. Seeds known and recognized to contain hard seed are legumes and many others.

6. Dormant seeds: Viable seeds, other than hard seeds, which fail to germinate when provided the specified germination conditions for the kind of seed in question.

7. Prechill: Placing the seed, on or in moist substrata at the indicated low temperature for the specified period of time.

The percentage germination reported on the Analysis Certificate indicates the proportion of seeds which have produced seedlings classified as normal according to these rules under the conditions and within the time specified (Table 2).

2. General Conditions

All germination tests are to be made with seeds from the "Pure Seed" separation. The definitions for "Pure Seed" and "Inert Matter" must therefore be applied uniformly in the purity analysis; otherwise there may be an increase in the variation between germination results.

The "Pure Seed" should be well mixed and then at least 400 seeds of each kind being tested should be counted at random in equal replicates of 100 or fewer. The average germination of all replicates represents the result of the test, provided that the difference between the highest and the lowest does not exceed the following limits:

10% for seed with an average germination of 90% or more;
12% for seed with an average germination of 80-89%;
15% for seed with an average germination less than 80%.

If the difference does exceed these limits a retest must be made. (In tests where replicates contain less than 100 seeds the results should be combined at random to form composites of 100 and the limits applied to these.)

The seeds should be spaced uniformly on the substratum and separated sufficiently to prevent the seedlings, as far as possible, from coming into contact before they are counted and removed. The time for the first and final counts is given in Table 2, but intermediate counts may be made at the discretion of the analyst after the seedlings have reached a sufficient stage of growth for all the essectial structures to be evaluated.

3. Processes In Seed Germination:

The processes which normally occur in an individual seed during germination may be briefly stated as follows:

1. Imbibition of water: Most seeds when mature and dry enough to store have a low moisture content ranging from 5 or 6 to 12 or 14 percent. The primary prerequisite for germination of a viable seed is to absorb water and until that occurs no other normal germinative processes can take place. Seeds vary in the amount of water which can be absorbed. Bean seeds will more than double in weight if soaked in water for 24 to 36 hours. Corn seeds will germinate more rapidly if the embryo is placed next to a moist surface rather than the endosperm side. The reason for this response is that growth is initiated in the embryo and the sooner the moisture reaches the plumule and radicle the sooner germination occurs. Water is the solute in which substances can be dissolved and moved hence its importance in growth. Water also softens the seed coats and facilitates the exchange of gases during germination.

2. Secretion of enzymes: In general the reserve foods stored in seeds are starches, hemicelluloses, proteins and fats all of which are insoluble in water. They must be changed to a soluble form. The enzymes are secreted within or outside the cells of the seed.

3. Break down of stored food: There are enzymes which decompose carbohydrates, others work on hemicelluloses and still others decompose proteins and fats. Gradually the stored foods are decomposed to form soluble foods such as sugars.

4. Translocation of soluble food: The soluble foods are moved from the place of decomposition to the growing points of the embryo by the processes of imbibition and osmosis. In caryopses of the grass family the major portion of stored food is in the endosperm with smaller portions in the embryo. In seeds with little or no endosperm the food is stored in the cotyledons to which the growing points are attached at the cotyledonary node. In either case enzymes are responsible for food breakdown.

5. Respiration with release of energy: A part of the soluble sugars is oxidized during respiration; carbon dioxide, water and energy are released and the energy is used to promote growth. The balance of the soluble food is used to provide basic food for the increase in size of the seedling.

6. Growth of the embryo: The first evidence of growth is cell division which occurs in the meristmatic region of the radicle attached at the lower end of the hypocotyl. Cell division also occurs in the plumule followed by cell differentiation in both regions.

4. Germination Conditions:

The more important germination conditions, except moisture level of the substrata, are set out in Table 2. Deviations from these methods are permitted only for seeds which do not respond to the prescribed test conditions. When dormancy is suspected, the special methods recommended in Table 2, column 7, may be used; otherwise, the method should be shown on the Analysis Certificate.

1. Substratum:

For testing seed germinative capability, seed must be placed on certain kind of medium which can provide the germinative seeds and seedlings with a supporting base to erect itself, to supply water. It should be (1) nontoxic to the germinating seedlings; (2) relatively free of molds, other microorganisms, and their spores, and (3) providing aeration and moisture for the germinating seeds.

Due to the large quantity of the substrata to be used for testing seeds by almost every seed testing laboratory, the economical factor should also be considered in selection of the most suitable kinds of substrata. The following are the most common in using by the seed testing laboratories:

1) Blotters: Many big paper manufacturing companies produce blotters for seed germination although white circular blotters 9 cm. in diameter are available for use in petri dishes.

"B" -- In the rules the capital letter "B" indicates "Between blotters" which means a single blotter folded over so the seeds may be placed between the upper and lower folds.

"TB" -- It means "on top of blotters."

In no case should the folded blotters be placed more than two deep on a tray, and their position should be alternated at the time of each preliminary count.

Seeds of rice, sorghum, wheat, millets, clovers, rye, and barley and many small vegetable crop seeds may be tested between blotters and large seeds, such as corn, beans, peas, squash and watermelons, respond better in other media.

2) Paper Towel: Paper towels can be rolled with the seeds enclosed within and placed either in a horizontal or vartical position on the trays.

"T" -- between folded paper toweling.

"B" -- rolled towels.

3) Sand and soil: For large seeds like corn, beans, peas, peanuts, squash, watermelon the most satisfactory method is to use sand as the medium for germination test. A container 15 x 26 x 30 cm. is large enough for 100 large seeds of the kind listed above. The sand particles should not larger than 0.8 mm. or smaller than 0.05 mm. in diameter. Sand should be sterilized after each use. Proper watering is of paramount importance, and if an excess is used at any time, maximum germination may not be achieved. Water should be added until the consistency of the sand is such that a ball is formed by squeezing in the palm of the hand but will break freely when pressed between two fingers or dropped.

The first step in the preparation of sand is to sieve it in order to remove any large particles or foreign bodies and to obtain sands of proper sizes. Then water is added gently. The sand should be well mixed or be passed through a coarse mesh sieve (about 4 mesh per inch) to insure a more even moistening and aeration of the substratum.

At least one-half inch of sand should be placed in the bottom of the container to be used for the laboratory test, and should be carefully leveled off. The seeds may be placed by hand or with a mechanical counting plate, care being taken to gently force the seeds part way into the substrata so that they will remain in place while being covered. The depth of the covering will vary somewhat with the size of the seed being tested, ranging from approximately one-fourth of an inch for clovers to one-half to three-fourths of an inch for corn and beans. The placement of damp blotters over the sand or soil boxes until the seedlings emerge will help in the maintenance of the initial moisture supply of the substrata. Care must be exercised not to overwater the sand for the duration of the test.

Soil is not commonly used for testing seed germination due to its complex properties. But if it is to be used, a sandy loam soil with a moderately high water-holding capacity is a suitable soil type. According to the International Rules for Testing Seeds, when tests are made with paper substrata and the accumulation of toxic substances is apparent, from the development of abnormal seedlings, retests shall be made in sterile soil.

Soil should be non-caking, and sieved to remove large particles before using it. If soil contains clay that may cause caking, a sufficient quantity of sand should be added to overcome this condition.

"S" -- stands for sand or soil.

The following formula is to be used as a basic guide in the preparation of sand:

$$\frac{118.29 \text{ cc. sand}}{\text{Its weight in grams}} \times 20.2 - 8.0 = \text{The number of cc. of water to add to each 100 grams sand.}$$

4) Filter Paper: Two layers of filter paper are usually used for petri dishes for testing seed germination. The use of petri dishes is suitable for small seeds.

5) Porous procelain or clay dishes standing in water or on moist sand may be used in lieu of TP (top of paper) substrata where the latter is indicated in Table 2. When

porcelain or clay dishes are used, the temperature should be maintained at that indicated for TP (top of paper) and JA (Jacobsen Apparatus) tests.

2. Temperature: Provision is made in Table 2 for use of two temperature alternations for many kinds of seeds. This permits the use of the Jacobsen Apparatus or so called Copenhagen Tank, as well as conventional germination cabinets and rooms. It is permissible to allow the 20°C constant temperatures to run as low as 18°C but should not exceed 21°C. Alternating temperatures should be held at the lower temperature for approximately 16 hours per day and at the higher temperature for approximately 8 hours per day. The temperature changes should be sharp for seeds which are likely to be dormant, particularly certain grasses. Gradual changes are usually satisfactory for non-dormant seeds.

3. Light: Most kinds of seeds requiring light for germination are tested at alternating temperatures, as indicated in Table 2. Light should be provided for the duration at the higher alternating temperature, except as otherwise indicated. Either natural or artificial light is effective but in making light available the specified temperatures must be maintained. For seeds that are likely to be dormant the light intensity should be between approximately 750 and 1250 lux (approximately 75 to 125 ft. candles.)

4. Moisture and Aeration: The initial amount of moisture should be supplied according to the nature and the dimensions of the seed bed, but subsequent watering, if any, must be left to the discretion of the analyst. The substratum must be moist enough at all times to supply the needed moisture to the seeds but there is danger that in supplying excessive moisture the aeration of seeds will be restricted. Except as provided for those kinds of seeds requiring high moisture levels of the germination media, the substrata should never be so wet that a film of water is formed around the seeds. For most kinds of seeds, blotters or other paper substrata should not be so wet that by pressing, a film of water forms around the finger. The amount of water that should be added to sand depends on the characteristics of the sand and size of seed to be tested. Each station should determine for each seed group the amount of water required for the sand it uses. Measured amounts should then be used regularly in routine testing. Cereals, except maize, may be germinated in sand moistened to 50 percent of its water-holding capacity, while the sand in which large-seeded legumes and maize are germinated should be moistened to 60 percent of its water holding capacity.

In preparing soil tests, water should be added until the consistency of the soil is such that a ball is formed by squeezing in the palm of the hand but when pressed between two fingers that ball will break easily. After the soil is wet it should be rubbed through a sieve and put in the containers for the test, without packing.

To prevent loss of moisture, sand and soil tests should be covered with moist blotters or glass plates until the seedlings begin to emerge. The addition of water subsequent to placing the seed in test will depend on the evaporation from the substrata in the germination chambers. Since the rate of evaporation will depend on the relative humidity of the air, it is desirable to keep water in the germination chambers or to provide other means of supplying a relative humidity of approximately 90 to 95 percent. Germination tests should be observed at frequent intervals to insure an adequate moisture supply of the substrata at all times.

5. Procedures of seed germination test:

1. Number of Seeds: At least 400 seeds shall be tested for germination except that in mixtures, 200 seeds of each of those kinds present to the extent of 15 percent or less may be used in which case an added to the regular germination tolerances. The seed shall be tested in replicates of 100 seed or less.

2. Source of Seeds: The seeds for germination test should be carefully taken from the portion of pure seeds. According to the International Rules, the "Pure Seed" should be well mixed and then at least 400 seeds of each kind being tested should be counted at random in equal replicates of 100 or fewer. But there is more detailed regulations by the Association of Official Seed Analysts of the United States concerning the source of seeds for germination test.

   (1) When both purity and germination tests are required, seeds for germination shall be taken from the separation of the kind, variety or type considered pure seed and shall be counted without discrimination as to size or appearance.

   (2) When only a germination test is required and the pure seed is estimated or determined to be at least 98 percent, the pure seed for the germination test may be taken indiscriminately from a representative portion of the bulk.

(3) When only a germination test is required and the pure seed is found to be less than 98 percent the pure seed shall be taken indiscriminately from a pure seed separation made according to the provisions of these rules and regulations which govern the separation of the kind, variety, or type considered pure seed except that other crop seeds, inert matter, and weed seeds need not be separated.

3. Obtaining the seeds: The actual obtainment of seeds for germination test can best be done by using of a mechanical divider. If it is not available, the bulk sample can be divided by hand. Small bulks may be poured directly into a small mixing pan and stirred by hand. Then spread out in a layer of uniform thickness and be repeatedly divided to obtain an approximately right amount of seeds. The method used to obtain a sample for purity analysis by mixing by hand can also be applied. The use of vacuum counter for the counting and seeding of the seeds will greatly facilitate the proceed of the germination tests. Vacuum counters are now regarded as a standard seed laboratory equipment which is designed to avoid personal bias in selecting seed and will increase the speed of placing the seed in test and spaced it evenly on the substrata.

4. Spacing the seeds: The proper spacing of seeds to reduce to the minimum the contact of seedlings with each other during germination is very important. There have been no regulations with respect to spacing of seeds, but the following is recommended:

> "The distance between seeds should be not less than 1½ to 5 times the width or diameter of the seed, the basis of spacing being the size of the seed to be tested."

5. Special Treatment for Dormancy: When a proportion of fresh or dormant seeds remain at the end of the test period complete germination can often be obtained by retesting after a period of dry storage. The following methods may also be used to induce germination in addition to the specific recommendations made in Table 2, Column 7.

(1) Prechilling: The replicates for germination are placed in contact with the moist substrata and kept at a low temperature for an additional period before they are removed to the temperature shown in Table 2, Column 3.

Agricultural and vegetable seeds are kept at a temperature between 5°C for an initial period up to 7 days. Tree seeds are kept at a temperature between 3°C and 5°C for a period, varying with the species, from 7 days to 12 months. In some cases it may be necessary to extend the prechilling period or rechill. The prechilling period is not included in the germination test period but both the duration and the temperature should be reported on the Analysis Certificate.

(2) Predrying: The replicates for germination should be heated at a temperature not exceeding 40°C with free air circulation for a period of up to 7 days before they are placed under the prescribed germination conditions. In some cases it may be necessary to extend the predrying period. Both the duration and the temperature should be reported on the Analysis Certificate.

(3) Potassium Nitrate: The germination substratum may be moistened with a 0.2% solution of KNO_3, prepared by dissolving 2 grams in 1,000 ml of water. The substratum is saturated at the beginning of the test but water is used for moistening it thereafter. The use of this treatment should be noted on the Analysis Certificate.

(4) Low temperature germination: The germination test may be made a lower constant temperature, or at a lower temperature alternating with the high temperature, as given in Table 2, Column 3. Germination may be slower and the test period can therefore be extended by an additional period equivalent to that given in Table 2, Column 6. Both the temperature and the duration of the test period should be reported on the Analysis Certificate.

(5) When germination is affected by a naturally occurring substance in the seeds, which acts as an inhibitor, it may be removed by soaking and washing in water before the germination test is made. Both the duration of the treatment and the water should be reported on the Analysis Certificate.

6. Seedling Evaluation:

(1) Definitions: In the germination test it is necessary to separate the normal seedlings, which are counted in the percentage germination, from any abnormal seedlings which have no practical value for producing plants. To achieve uniformity in evaluation one of the following definitions shall be applied:

(2) Normal Seedlings:

a) Seedlings which, if grown in good quality soil, free from disease organisms, nematodes, or foreign seeds, under favorable conditions of temperature, water supply, and light, show the capacity for continued development into normal plants.

b) Seedlings which possess all the following essential structures:

i. A well-developed root system including a primary root except for those plants (e.g. certain species of Gramineae) normally producing seminal roots of which there should be at least two.

ii. A well-developed and intact hypocotyl without damage to the conducting tissues.

iii. An intact plumule or epicotyl with a well-developed leaf within, or emerging through the coleoptile or an intact plumular bud.

iv. One cotyledon for monocotyledons and two cotyledons for dicotyledons.

c) Seedlings with the following slight defects should be counted as normal provided they show vigorous and balanced development of the other essential structures.

i. Seedlings of Pisum, Vicia faba, Phaseolus, Lupinus, Vigna, Glycine, Arachis, Gossypium, Zea, and all species of Cucurbitaceae with no primary root but with two or more secondary roots of sufficient length and vigor to support the seedling in soil.

ii. Seedlings with superficial damage or decay to the hypocotyl, epicotyl or cotyledons which is limited in area and does not effect the conducting tissues.

iii. Seedlings of dicotyledons with only one cotyledon.

(3) Abnormal Seedlings:

a) Abnormal seedlings are those which, if grown in good quality soil, free from disease organisms, nematodes, or foreign seeds, under favorable conditions of temperature, water supply, and light, do not show the capacity for continued development into normal plants.

b) Seedlings with the following defects are classed as abnormal:

i. Damaged seedlings: Seedlings with no cotyledons; seedlings with constrictions, splits, cracks, or lesions which affect the conducting tissues of the epicotyl, hypocotyl or root; seedlings without a primary root of those kinds where a primary root is an essential structure except for Pisum, Vicia faba, Phaseolus, Lupinus, Vigna, Glycine, Arachis, Gossypium, Zea, and all species of Cucurbitaceae where sufficient secondary roots have developed to support the seedling in soil.

ii. Deformed seedlings: Seedlings with weak or unbalanced development of the essential structures such as spirally twisted or stunted plumules, hypocotyls or epicotyls; swollen shoots and stunted roots; split plumules or coleoptiles without green leaves; watery seedlings, or those without further development after emergence of the cotyledons.

iii. Decayed seedlings: Seedlings with any of the essential structures so diseased or decayed that normal development is prevented, provided there is no evidence to show that the cause of infection was other than the seed itself.

iv. Tree seedlings: Seedlings showing cotyledon development from the micropyle, or radicle development from a part of the seed other than the micropyle.

7. Reporting Results:

When the variation between replicates does not exceed the limits indicated in section VII, C, (B), the average of all replicates shall be considered the result of the test. The result of a germination test shall not be reported on an International Analysis Certificate if the difference between the highest and lowest germinations of the 100-seed replicates

exceeds these limits. Results of retests, and concurrent tests made by different prescribed methods, shall be averaged, provided: (1) the replicates meet the above conditions, and (2) the results are within tolerance of each other; otherwise, the higher result is to be reported. For allowable tolerances, see Table 7.

8. Examples

A. Gramineae (Rice, wheat, corn, sorghum and barley)

The International Rules regulated the following conditions for germination tests of the above-listed seeds:

Kind	Substrata	Temperature	First count	Final count
Rice	BP; JA	20-30	5	14
Sorghum	BP; S	20-30	4	10
Corn	RP; S	20-30	4	7
Wheat	BP; S	20	4	8
Barley	BP; S	20	4	7

1. 400 seeds are taken at random from the portion of pure seed. Using vacuum seed counter or other counting equipments can facilitate the seed counting and also will make no mistakes.

2. Folded towel tests are indicated in the rules for testing seeds of rice, wheat, and barley. Folded blotters are suitable for sorghum but not desirable for rice seeds, since they do not provide enough moisture, and are too small to accomodate even 50 rice seeds without undue crowding. After the seeds have absorbed water, the blotters should be kept slightly dry, especially on tests of forghum.

3. The usual amount of moisture should be maintained on these tests, except for rice, which should be wetter than average, especially during the initial stages of germination.

4. Dormancy may be encountered in testing most of the Gramineae listed in the rules. The analyst should examine carefully those ungerminated seeds remain on/in the substratum at the end of the tests whether they are dormant seeds. (Dormant seed usually absorb water during germination test, but remain fresh-looking and viable.) If so,

retests should be made under some other conditions. The regular treatment for dormant samples of seeds of this category is to prechill them at 5° or at 10°C for 5 days, and then place them at 20°C. More water supply than ordinary germination test for rice would tend to overcome dormancy of rice. Flooded sand tests have proved successful too.

5. Seedling interpretation: The plumule in the grass family appears above the ground and the first foliage leaf is enclosed in a white sheath called coleoptile, the pointed tip of which is broken open as the leaves elongate. As the seedling grows, permanent roots arise from the base of the first foliage leaf, and other whorls of permanent roots arise from the nodes above. The primary root system is temporary and soon dies.

A perfect grass seedling should have a well-developed primary root system, an intact cotyledon or scutellum, a strong, vigorous plumule with long, well-developed green leaves within the coleoptile. One or more leaves may have broken through the coleoptile by the end of the test period. Seedlings should not be removed from test until they have developed to a stage whereby the structure, color, and general condition of the plumule and primary root system can be observed.

(1) Rice: Development of fungi on seeds and seedling may cause extreme variation in test results. More uniform results will be obtained if samples are well spaced and grown in "flooded" sand or soil or placed in upright rolled towel tests.

A) Normal Seedlings include those that have:

a) One primary root, usually with numerous lateral roots; several permanent roots arising from the first node should be present if seedlings are not removed until the end of the test;

b) Well-developed green leaves which ordinarily should have broken through the coleoptile at the time the seedling is evaluated;

c) Slight infection by fungi, provided none of the essential seedling structures have been damaged.

B) Abnormal seedlings include those that have:

a) no roots;

b) a spindly primary root with very little or no branching or secondary development;

c) no green leaves, but only the white sheath or coleoptile;

d) a spindly and sometimes watery shoot which is usually associated with decay of the rice grain;

e) a short leaf, extending no more than one-half the distance up through the coleoptile;

f) shattered or longitudinally split plumules with or without splitting of the coleoptile;

g) decayed plumules, provided the decay is not the results of improper test conditions (the plumules usually are weak appearing and show decay near the point of attachment to the grain);

h) various combinations of the above-named abnormal types.

Rice Seedlings 水稻幼苗

Normal （正常） —1,2,3

Abnormal （不正常） 4~20

(2) Corn:

A) Normal seedlings include those that have:

a) one primary root, usually with secondary roots present;

b) no primary root, but with at least two vigorous secondary roots, provided the grain is not badly decayed, and the shoot is well developed;

c) well-developed green leaves, usually broken through the coleoptile by the end of the test period;

d) twisted and curled shoots bound by the tough seed coat, provided the shoot is not decayed;

e) slight infection by fungi, provided none of the essential seedling structures have been damaged.

B) Abnormal seedlings include those that have:

a) no primary or secondary roots;

b) no primary root but small and weak secondary roots;

c) no plumule, but only the white sheath or coleoptile;

d) a shortened plumule, extending no more than one-half the way up through the coleoptile;

e) a thickoned and shortened shoot; often the result of overtreatment of seed with chemicals;

f) a spindly and pale shoot usually associated with moldy seeds;

g) albino (entirely white) seedlings, which will not develop into plants because of lack of chlorophyll;

h) shattered or longitudinally split leaves, with or without splitting of the coleoptile;

i) decayed shoots, provided the decay is not the result of improper test conditions (the plumules usually appear weak and show decay near the point of attachment to the grain and the scutellum is usually rotten);

j) various combinations of the above-named abnormal types.

Corn seedlings 玉米幼苗

Normal （正常） *—1*

Abnormal （不正常） *—2~5*

(3) Sorghum:

A) Normal seedlings include those that have:

a) one primary root, usually with well-developed secondary roots and root hairs if left for final counts in soil tests.

b) well-developed, green leaves, usually broken through the coleoptile by the end of the test period;

c) slight infection by fungi, provided none of the essential seedling structures have been damaged;

d) red coloration on the roots and on the coleoptile of the shoot, caused by natural pigments, provided the seedling is otherwise normal.

B) Abnormal seedlings include those that have:

a) no roots;

b) a weak, spindly, and usually shortened primary root, which is often associated with decay of the grain;

c) no plumule, but only the white sheath or coleoptile;

d) a shortened plumule, extending no more than one-half the way up through the coleoptile;

e) a spindly and pale plumule, usually associated with moldy seeds;

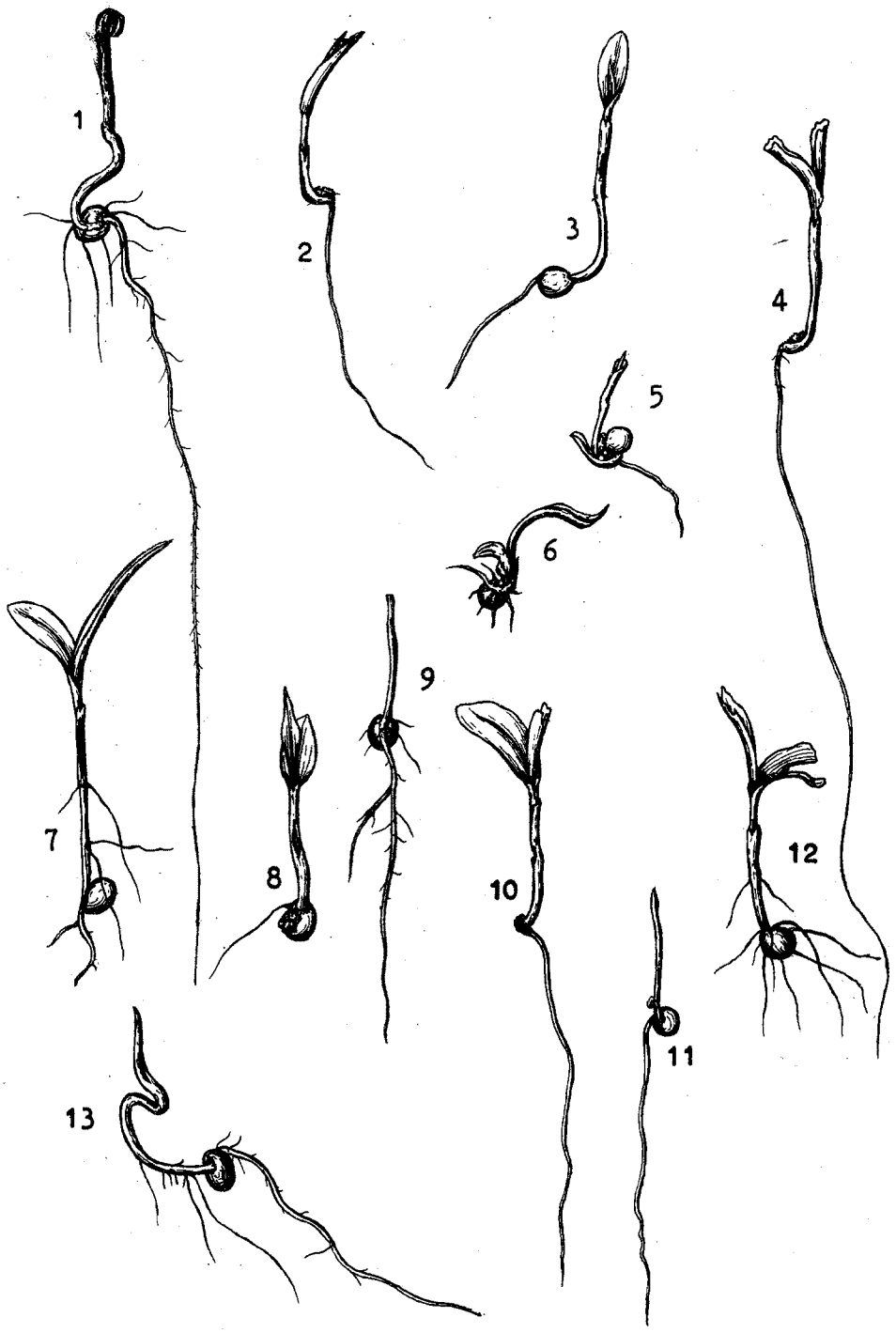
f) shattered and longitudinally split plumules, with or without splitting of the coleoptile;

g) decayed plumules, provided the dacay is not the result of improper test conditions (the plumules usually appear weak and show decay near the point of attachment to the grain which is usually rotten);

h) various combinations of the above-named abnormal types.

Sorghum normal seedlings

高粱正常幼苗



Sorghum abnorml seedlings

高粱不正常幼苗

(4) Wheat, barley and oats:

A) Normal seedlings include those that have:

a) at least one primary or seminal root, but preferably two or three seminal roots, provided the shoot is well developed and the grain is not badly decayed;

b) well-developed leaves, green in color, and long enough to extend more than half way up into the sheath or coleoptile at the time the seedling is evaluated;

c) spiral twisting or bending of the shoot, provided it is green in color, has normal length, and is not frost damaged;

d) slight infection by fungi, provided none of the essential seedling structures have been damaged.

B) Abnormal seedlings are those that have:

a) no primary root;

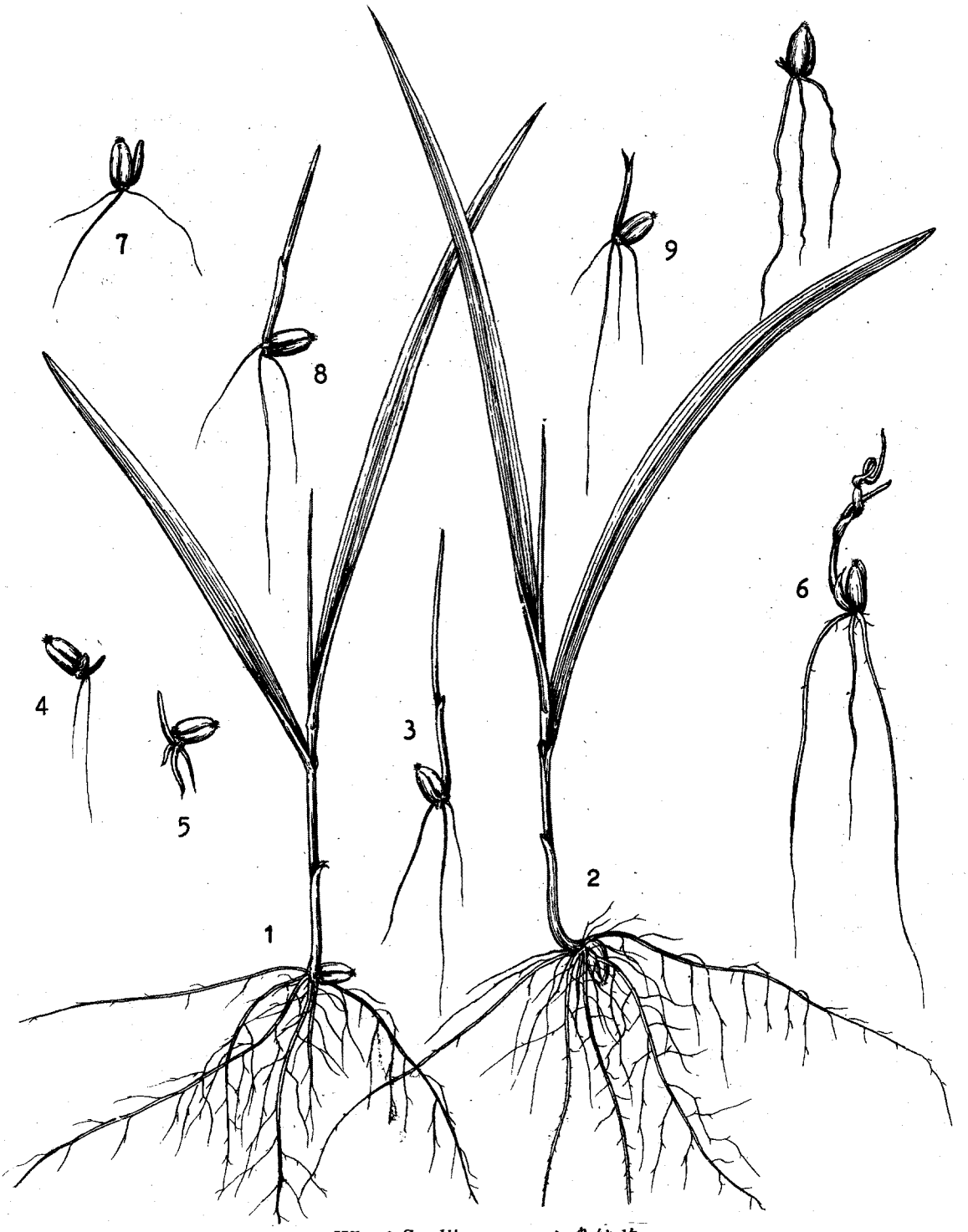
b) only one or two short or spindly seminal roots which are usually accompanied by weakened shoots and decayed grains;

c) no green leaves, but only the white sheath or coleoptile formed, which may or may not be grainy, spirally twisted split, or shortened;

d) a shortened shoot, extending no more than one-half the way up through the coleoptile;

e) a thin, spindly, or watery shoot usually accompanied by weak root development and decayed grains;

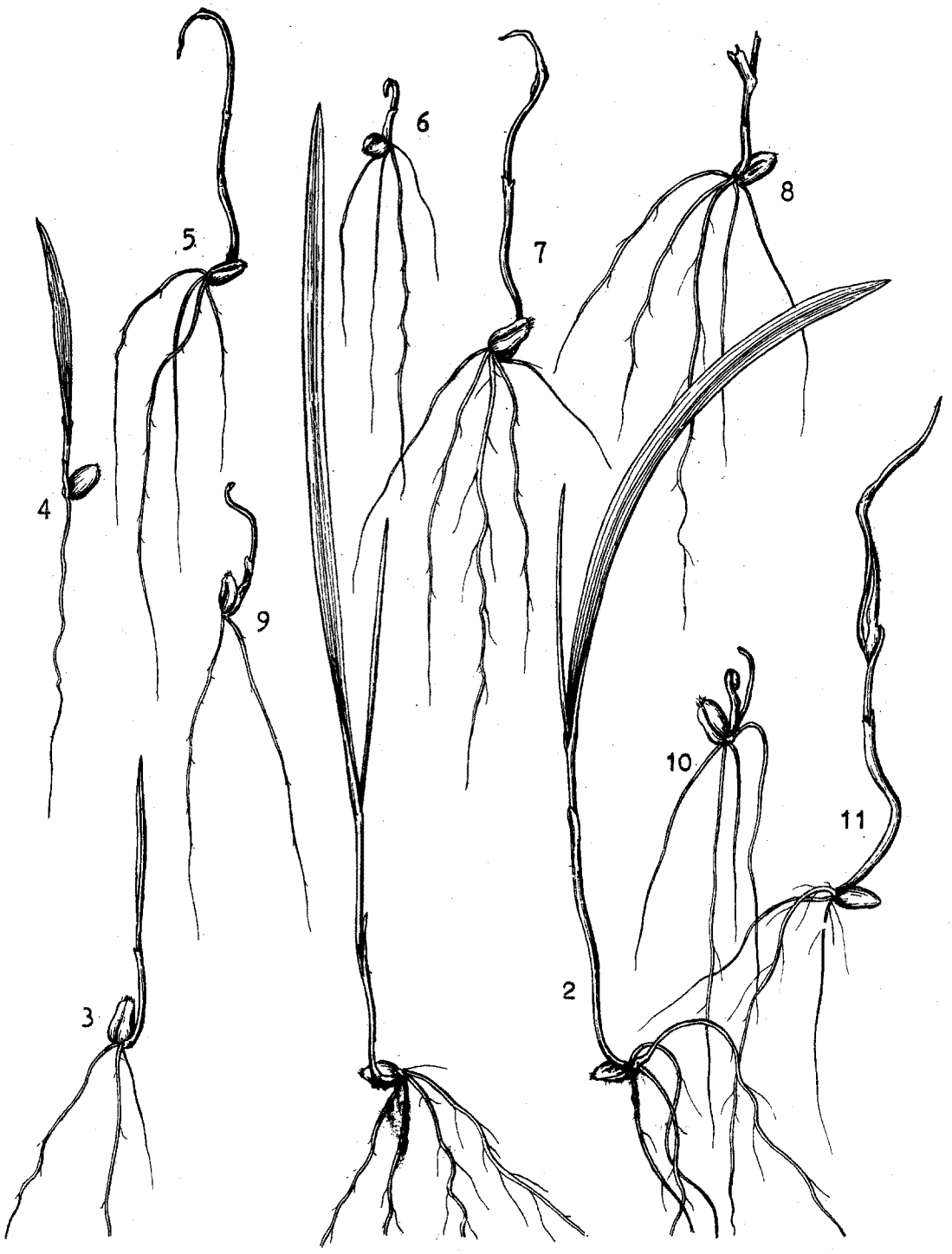
f) badly shattered or longitudinally split leaves, with or without splitting of the coleoptile;



Wheat Seedlings 小麥幼苗

Normal （正常） —*1,2*

Abnormal （不正常） —*3~10*



Barley Seedlings 大麥幼苗
Normal (正常) —*1,2*
Abnormal (不正常) —*3~11*

g) thickened and shortened shoot (leaves and coleoptile), often the result of over-treatment of seed with chemicals;

h) decayed shoots, provided the decay is not the result of improper test conditions; the shoots usually appear weak and show decay near the point of attachment to the grain which is usually rotten;

i) badly frost-damaged seedlings, characterised by grainy coleoptiles and spirally twisted leaves and coleoptiles; or coleoptile developed without the leaves (in soil tests, some of the longest of the spirally twisted seedlings will appear fairly strong but most of them break off just above the attachment of the plumule and coleoptile to the grain; the shortest of the seedlings do not emerge in soil tests;

j) various combination of the above-named abnormal types.

(5) Leguminosae (Legume family)

1. 400 seeds should be used for germination test. They are taken at random from the portion of pure seed.

2. The kinds of substrata to be used for testing legumes are: rolled towels, flat folded towels, folded blotters, and creped cellulose paper wadding. Sand and soil are also to be used especially to those kinds which may be particularly troublesome to interpret.

3. Large-seeded legumes will absorb a great deal of moisture during the first stages of germination, the substrata should be saturated with water at the time the tests are set up. After the seeds have absorbed water the moisture content of the substrata should be reduced to moderate damp to give only enough moisture to maintain seedling growth without excessive drying, in order to discourage decay and growth of fungi.

4. At the time of the first count all decayed seeds should be removed and recorded.

5. Only final count be made on all soil and sand tests, because it is possible to make a more accurate seedling evaluation when a comparison is made between the strong and weak seedlings.

6. Seedling evaluation: Legume seedlings may exhibit either hypogeous or epigeous growth. In epigeous development, the only underground part of the seedling is the root and the lower part of the hypocotyl. The latter lengthens and appears above the ground carrying the two cotyledons with it. The growth above the cotyledons forms the epicotyl consisting of a stem with terminal bud and two primary leaves. In hypogeous development, the underground parts of the seedling are the root, the very shortened hypocotyl, and the two cotyledons. The epicotyl elongates above the cotyledons and emerges from the ground forming the stems and leaves.

(1) Epigeous types of germination: Beans (garden, field, lima, adzuki, mung, asparagus), cowpea, lupines, peanuts, soybean, clovers, alfalfa, black medic, trefoil, crotalaria, lespedeza, kudzu, sesbania, sainfoin.

If preliminary counts are made before the cotyledons have opened, the analyst must part them manually in order to determine the condition of the primary leaves and the terminal bud. By the end of the germination test, a perfectly normal seedling should have a well-formed root, with or without secondary or advantitious development; a strong, fairly long stem or hypocotyl with two attached cotyledons, and two well-developed first or primary leaves and an intact terminal bud.

For seeds of peanuts and lupine, mechanical breakage often appears to interfere with the leaf development. But to those seeds of soybean and cowpeas, injury appears to be confined to the hypocotyl and roots rather than to the epicotyl. It might not be practical to open manually the cotyledons of all samples of soybeans on the preliminary counts, since epicotyl injury is not too common; but a few should be opened in each sample and if there is evidence of mechanical injury it may be necessary to open the cotyledons of all seedlings in that sample. If only a final count is made the epicotyl will usually have emerged from between the cotyledons, and the condition of the first leaves can be easily determined. Preliminary counts should be made on samples which show mold or bacteria that might spread to healthy seedlings.

Breaks at the point of attachment of the cotyledons to the hypocotyl, with injury to the epicotyl, are very common in seeds of small legumes which have been mechanically damaged.

By the end of the germination test a perfectly normal seedling should have a long, slender root with root hairs, with or without adventitious roots; a strong and fairly long hypocotyl with two attached, open cotyledons; two well-developed first or primary leaves, or sometimes only an intact epicotyl or growing point.

A) Normal Seedlings:

a) Have two primary leaves, or at least one primary leaf, even though one or both cotyledons are absent. The terminal bud must be present in either case.

b) Have a primary root or a set of adventitious or secondary roots sufficient to anchor it when grown in soil or sand, provided the hypocotyl is not badly shortened.

c) The normal seedling must have a fairly well-developed hypocotyl with no prominent breaks or deep lesions. Healed breaks, sometimes referred to as "knees", are to be considered as normal, provided the seedling is not spindly.

d) Normal seedlings may include those with slight infection from fungi, provided the essential structures have not been seriously damaged and appear to be able to carry on their normal functions at the time of evaluation. If a few seedlings with total or partial decay of the plumule are found, they may be counted as normal, provided the hypocotyl and root are well developed. However, if there are many seedlings with decayed plumules in a test, a retest should be made and such seedlings evaluated cautiously.

e) Spirally twisted and curled root and hypocotyl held within the tough seed coat, causing delayed development; otherwise normal. At the present time, due to lack of data, analysts may count such seedlings as normal, provided the essential parts are present.

B) Abnormal Seedling:

a) Stubby roots, usually associated with shortened hypocotyls;

b) No primary leaves or terminal bud (baldhead);

c) No primary leaves, but with a terminal bud (snakeheads or partial baldheads);

d) Both cotyledons broken off;

e) A malformed hypocotyl, which may be characterised by open splits, or appear curled, shortened, or thickened;

f) No primary root or well-developed set of adventitious or secondary roots;

g) One cotyledon broken off if the epicotyl is also absent;

h) Various combinations of the above-named abnormal types.

(2) Hypogeous type of germination: Field peas, garden pea, vetches, broad bean, velvet bean, runner bean, chickpea.

While examining a seedling of this group, it is necessary to wait until the epicotyl has broken through the seed coat and erected itself sufficiently, so the analyst may discern whether the epicotyl is intact.

By the end of the germination test a perfectly normal seedling should have: (1) a well-formed root, with or without secondary or adventitious development; (2) a strong epicotyl with fairly long stem; (3) a well-developed epicotyl with the leaves and terminal bud intact; (4) the seedling should not be broken away from the cotyledons.

A) Normal seedlings:

a) A primary root or a set of secondary or adventitious roots sufficient to anchor the seedlings when grown in soil or sand, provided the stem is not badly shortened;

b) a fairly well-developed stem with no prominent breaks or deep lesions which might interfere with the conducting tissues;

c) a terminal bud with at least one first leaf and an intact growing point;

d) two shoots, provided the seedling appears vigorous and at least one of the shoots has a normal epicotyl and root;

d) slight infection by fungi, provided the essential seedling parts have not been seriously damaged and appear to be able to carry on their normal functions at the time of evaluation.

B) Abnormal seedlings:

a) No primary root or well-developed secondary or adventitious roots;

b) a malformed stem, which may be characterized by severe open splits, and curled, shortened, or thickened development;

c) no epicotyl, or an epicotyl without the terminal bud;

d) two shoots, both of which appear weak and spindly, often partially broken away from the cotyledons;

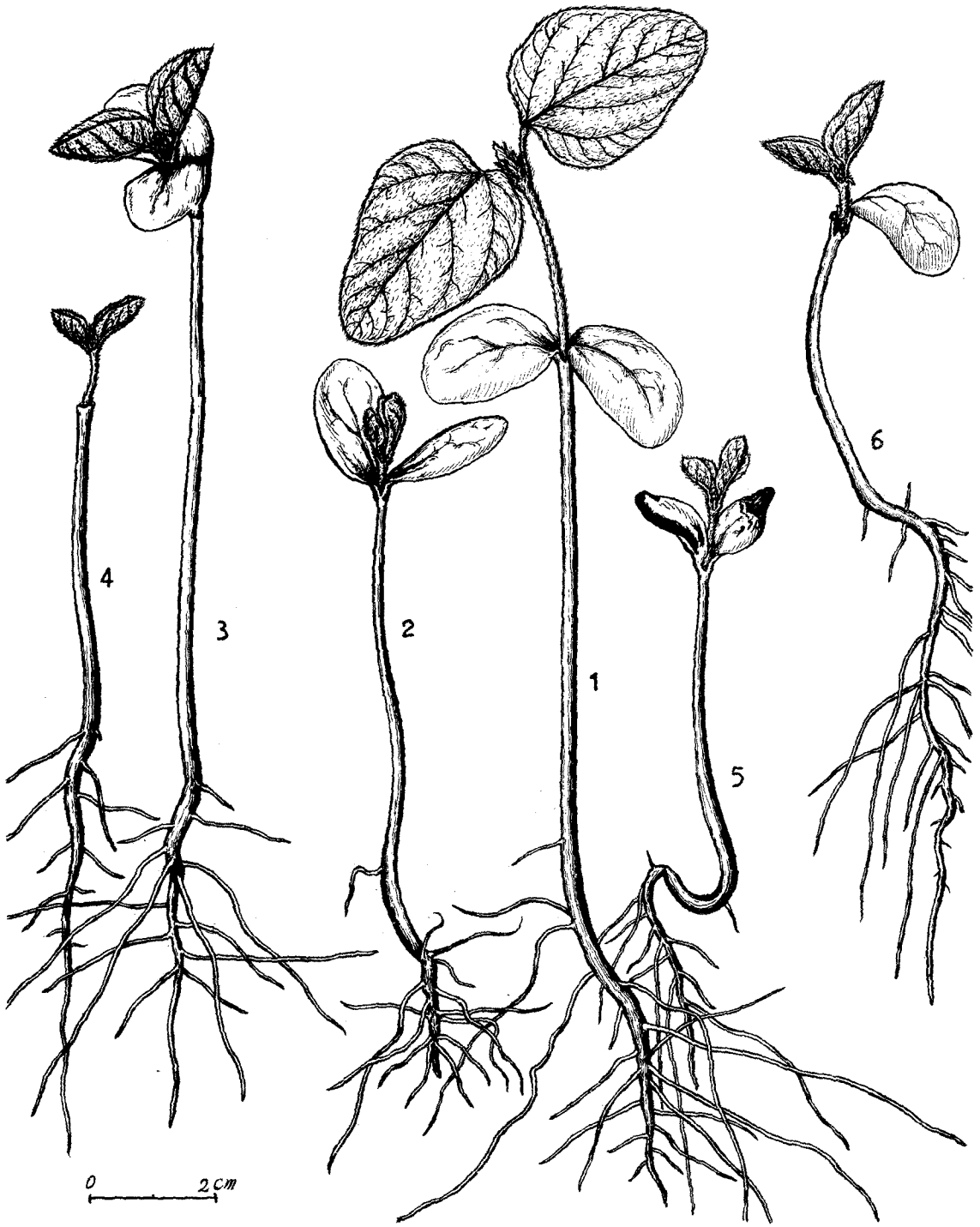
e) decayed seedlings caused by the spread of decay from the cotyledons of the developing seedling;

f) various combinations of the above-named abnormal types.

(6) Malvaceae (Mallow family) -- Cotton, kenaf

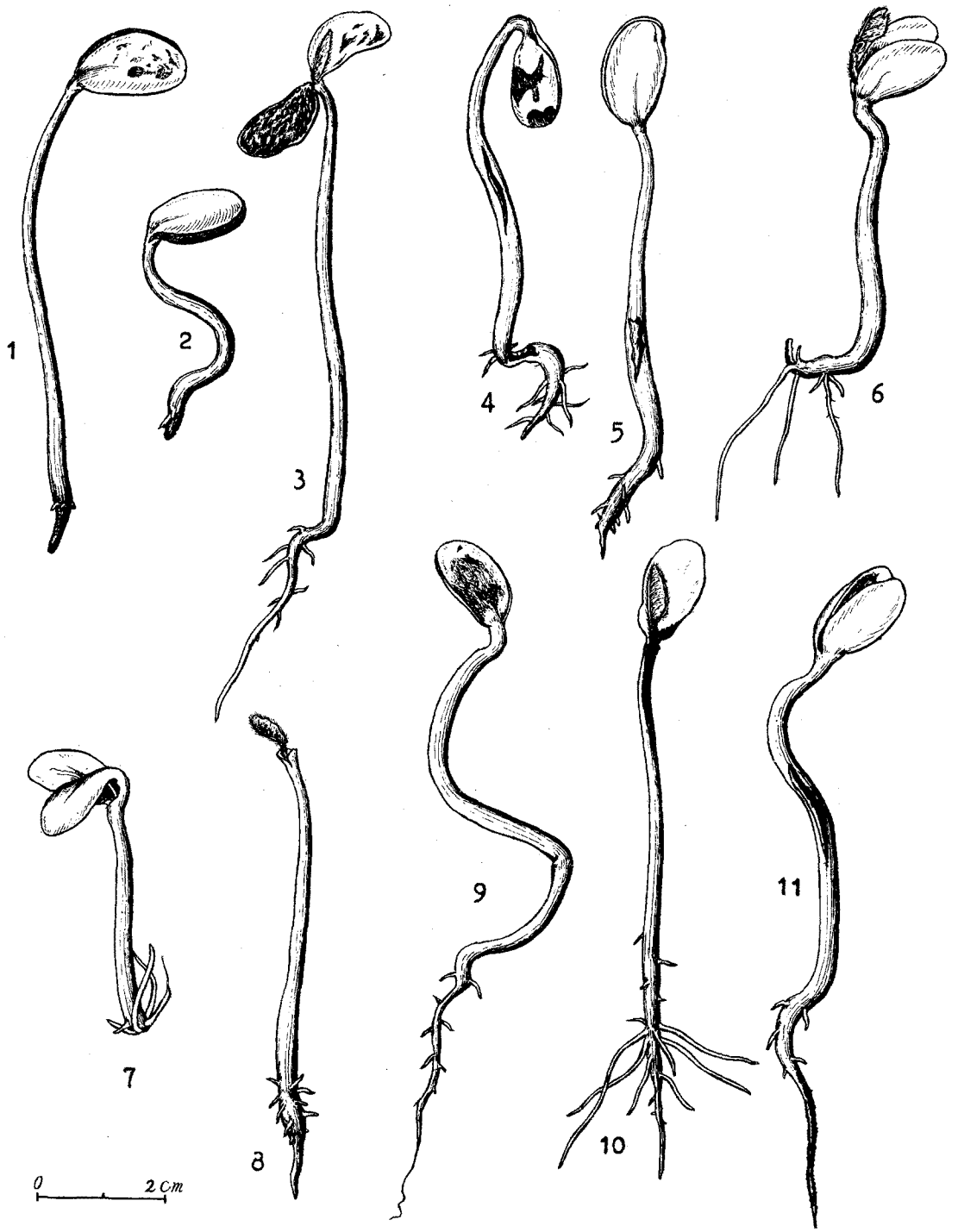
1. Rolled towels, paper towels, sand or soil are to be used for germination test of cotton and kenaf seeds.

2. Because of the fungi carried on the fuzzy seed coats, proper spacing of cottonseed is essential if uniform results are to be expected.



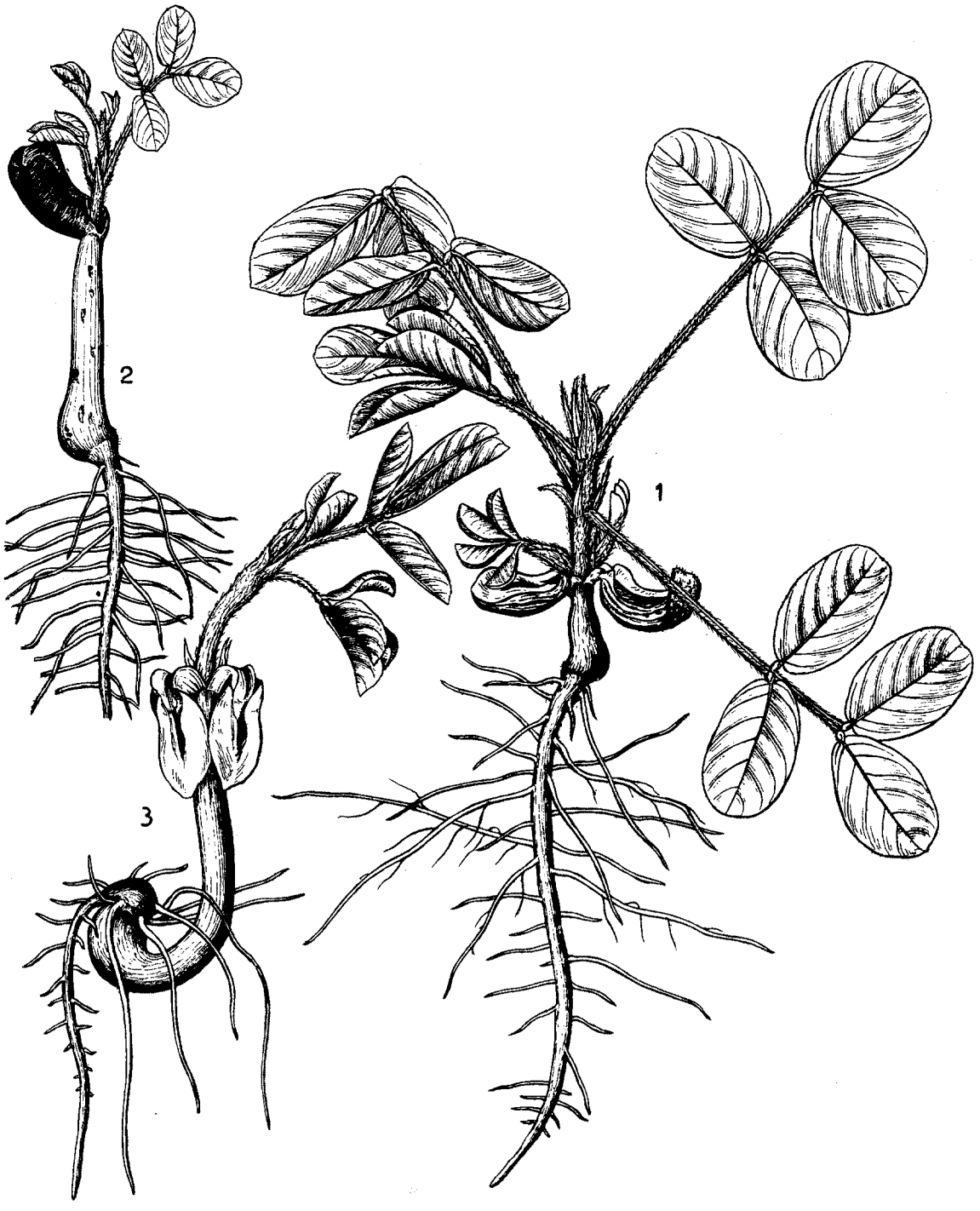
Soybean normal seedlings

大豆正常幼苗



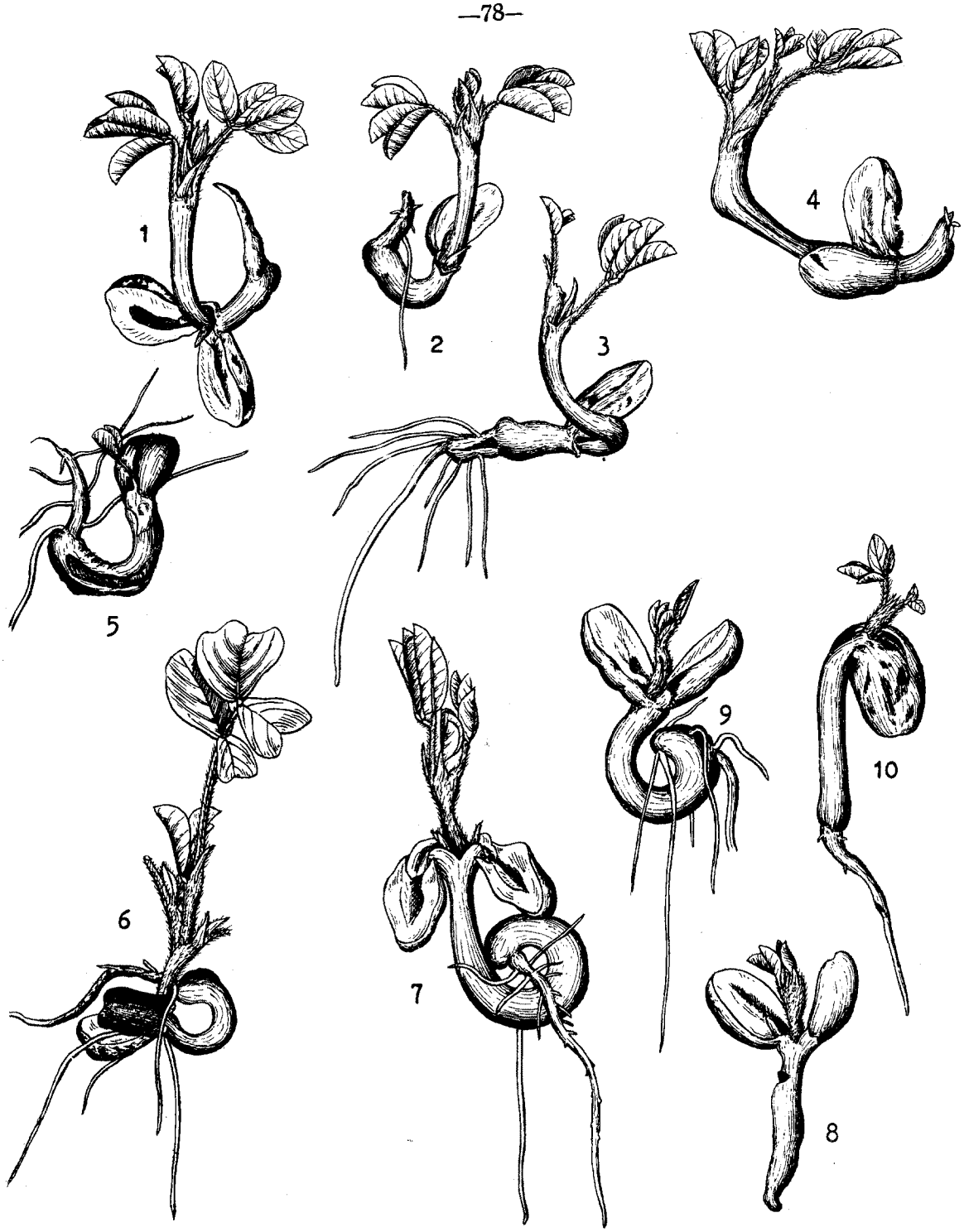
Soybean abnormal seedlings

大豆不正常幼苗



Peanut normal seedlings

落花生正常幼苗



Peanut abnormal seedlings

落花生不正常幼苗

3. Owing to the absorption of the added moisture by the lint on the seeds, faster germination is obtained by the pre-wet method, and the seedlings emerge before the fungi have a chance to develop.

By the end of the germination test a perfectly normal seedling should have a long, well-developed root with root hairs, a long hypocotyl, and two attached green leaf-like cotyledons, with a tiny epicotyl formed between them.

A. Normal seedling:

a) A well-developed, long, slender root, usually with root hairs;

b) no primary root but strong secondary roots, provided the hypocotyl is of normal or approximately normal length;

c) a long, well-developed hypocotyl with no breaks or deep grainy lesions which might interfere with the conducting tissues;

d) at least one cotyledon and intact epicotyl;

e) slight infection by fungi, provided none of the essential seedling structures have been damaged;

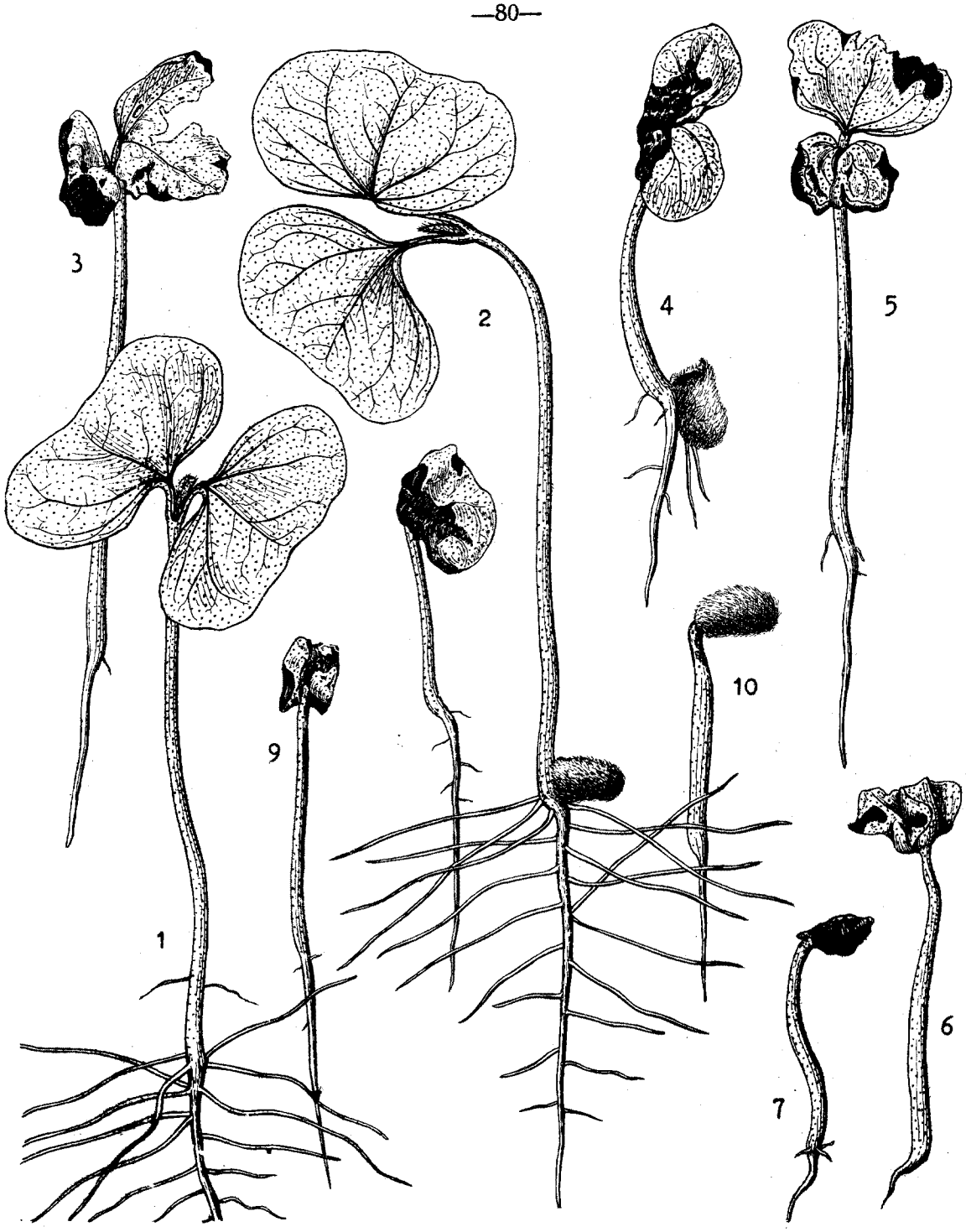
f) yellowish hypocotyls or roots of cotton which may appear diseased, provided the cotyledons are free of infection (the seed coat must be peeled back on young seedlings to determine this condition of the cotyledons).

B. Abnormal seedling:

a) No root or very stubby roots, usually associated with a shortened hypocotyl;

b) stubby roots and thickened hypocotyls resulting from chemical treatment of seed, such as often occurs on delinted cottonseed;

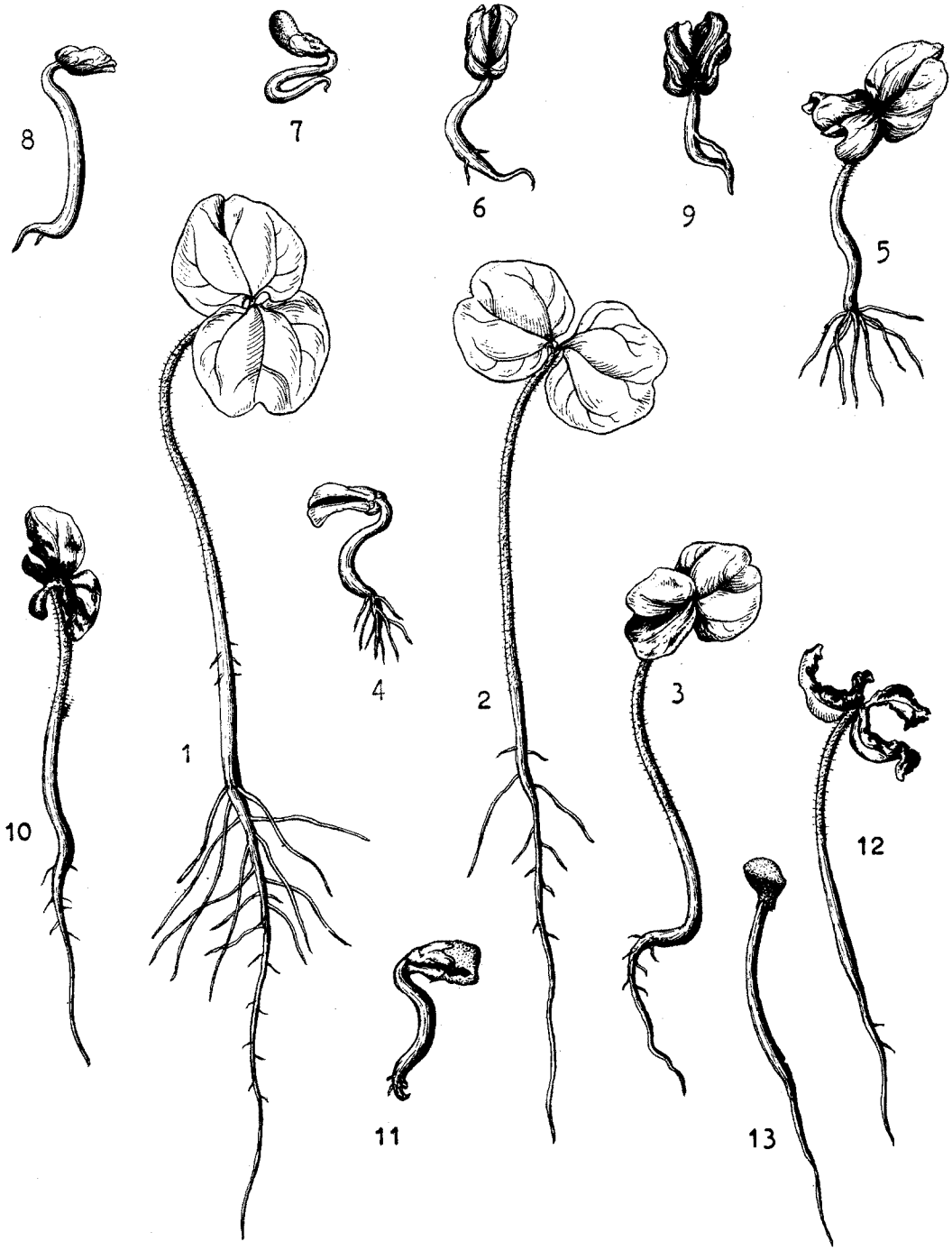
c) malformed hypocotyl, which may be curled, thickened, or shortened;



***Cotton** seedlings* 棉花幼苗

Normal （正常） —*1,2*

Abnormal （不正常）—*3～10*



Kenaf Seedlings 鐘麻幼苗
Normal (正常) —*1,2,3*
Abnormal (不正常) —*4~13*

d) deep cracks or grainy lesions on the hypocotyl which appear to interfere with the conducting tissues;

e) epicotyl absent, even though one or both cotyledons are attached;

f) decayed cotyledons and hypocotyls, provided the decay did not spread from another seed or was not the result of improper test conditions;

g) various combinations of the above-named abnormal types.

(7) Linaceae (Flax family) -- Flax

1. The standard procedure is to test flaxseed between blotters, but soil and sand are alternate substrata.

2. By the end of the germination test a normal flax seedlings should have a well-developed primary root, a long hypocotyl, two intact cotyledons, and a small epicotyl which does not develop sufficiently during the course of the laboratory test to be examined unless the seedlings are left for final evaluation and the cotyledons manually parted.

A. Normal Seedlings:

a) A long, slender root, usually with root hairs;

b) a short or stubby primary root, provided secondary root development is strong and the hypocotyl is of normal length or approximately so;

c) a long, well-developed hypocotyl with no breaks or lesions extending into the conducting tissues;

d) at least one attached cotyledon, provided the epicotyl is not injured;

e) variously broken or cracked cotyledons; provided the other seedling parts appear normal;

f) slight infection by fungi, provided none of the essential seedling structures have been damaged.

Flax Seedlings 亞麻幼苗

Normal (正常) —*1,2,3*

Abnormal (不正常) —*4~12*

B. Abnormal seedlings:

a) A stubby or no primary root, provided the secondary root development is weak, a condition usually associated with a shortened hypocotyl;

b) a malformed hypocotyl, which may be twisted, thickened, or shortened;

c) deep cracks or lesions on the hypocotyl, extending into the conducting tissues;

d) both cotyledons broken off;

e) one cotyledon broken off if the epicotyl is also injured;

f) decayed cotyledons or other essential seedling structures, provided the decay is not the result of improper test conditions;

g) various combinations of the above-named abnormal types.

(8) Cruciferae (Mustard family) -- Radish, cauliflower, rape, Chinese kale

1. Dormancy may occur in many of the kinds in this group, especially those of the genus Brassica.

2. B. juncea, B. nigra are apt to be dormant, whereas B. hirta and B. perviridis are not. Seeds of the B. oleracea group (broccoli, brassels sprouts, cabbage, cauliflower, collards, kale, and kohlrabi) are occasionally dormant. The use of potassium nitrate, light, and prechilling are recommended in the rules for overcoming dormancy in these kinds

Dormancy may also be encountered in B. campestris. It is unlikely that dormancy will be found in B. napus var. annua, B. campestris vars.

3. Seeds of this family may be tested between blotters. Blotters and petri dish are suitable for germination test.

By the end of the germination test, a perfectly normal crucifer seedling should have a well-developed root, usually with root hairs, a long hypocotyl, two intact green, leaflike cotyledons and a small but visible epicotyl or growing point.

A. Normal seedlings:

a) A well-developed, long, slender primary root with root hairs;

b) a well-developed, long hypocotyl with no prominent breaks or deep lesions which might interfere with the conducting tissues;

c) one or two cotyledons not decayed at the point of attachment to the cypocotyl, provided the epicotyl is also present;

d) slight decay at the base of one cotyledon, provided the epicotyl is not infected;

e) less than 50 percent of the area of the cotyledons covered with spots or darkened areas;

f) slight infection of roots or hypocotyl with fungi, provided none of the essential seedling structures have been damaged.

B. Abnormal seedlings:

a) No root or a stubby root, usually associated with a shortened hypocotyl;

b) a malformed hypocotyl, which may be curled, shortened, or thickened and usually associated with a stubby root;

c) deep, unhealed cracks or lesions on the hypocotyl, extending into the conducting tissues;

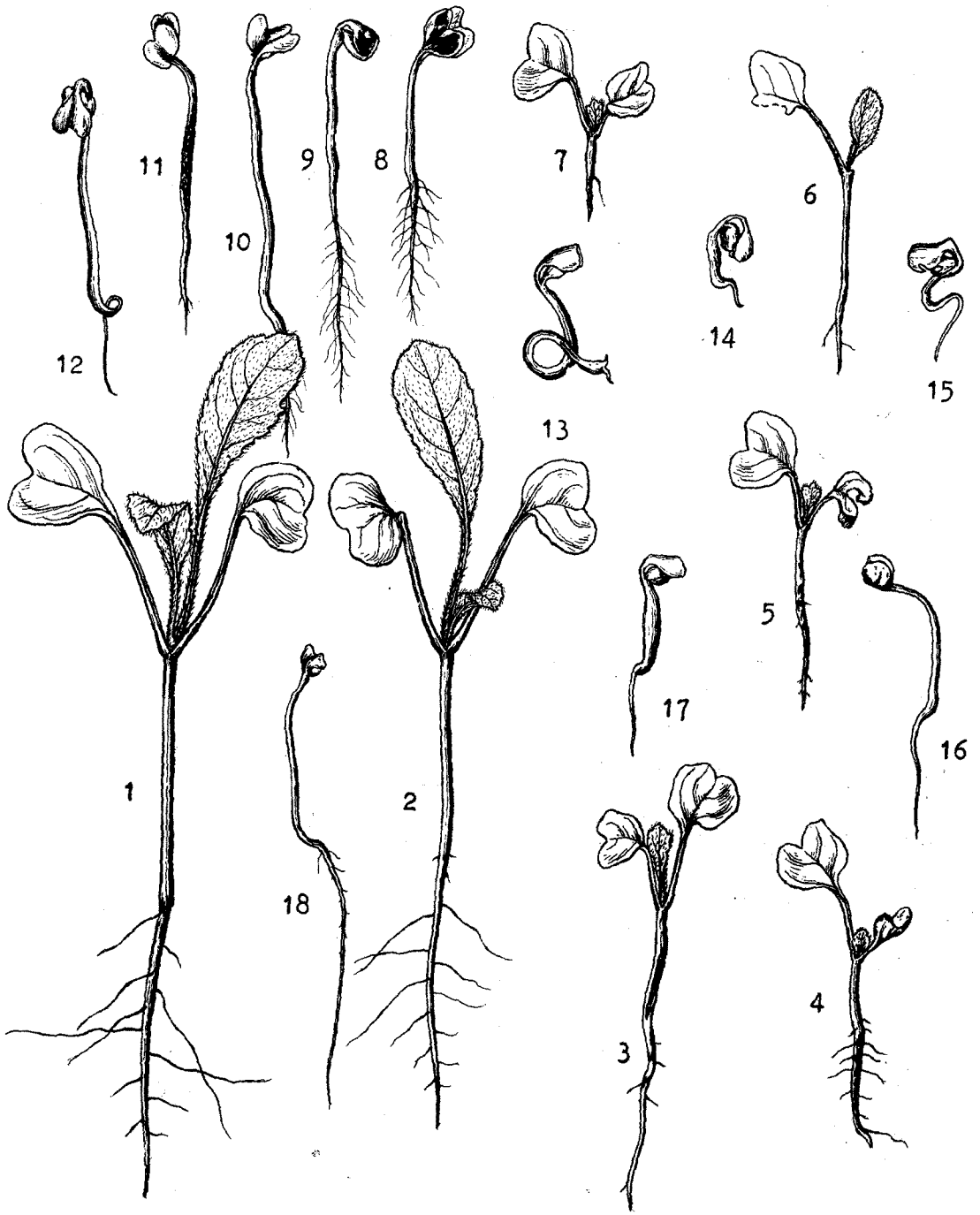
d) decay at the point of attachment of both cotyledons to the hypocotyl which may or may not involve the terminal bud;

e) decay at the point of attachment of one cotyledon to the hypocotyl, provided the terminal bud is also decayed;

f) 50 percent or more of the area of the cotyledons covered with spots or darkened areas;

g) decayed roots or hypocotyles, provided the infection was not caused by improper test conditions;

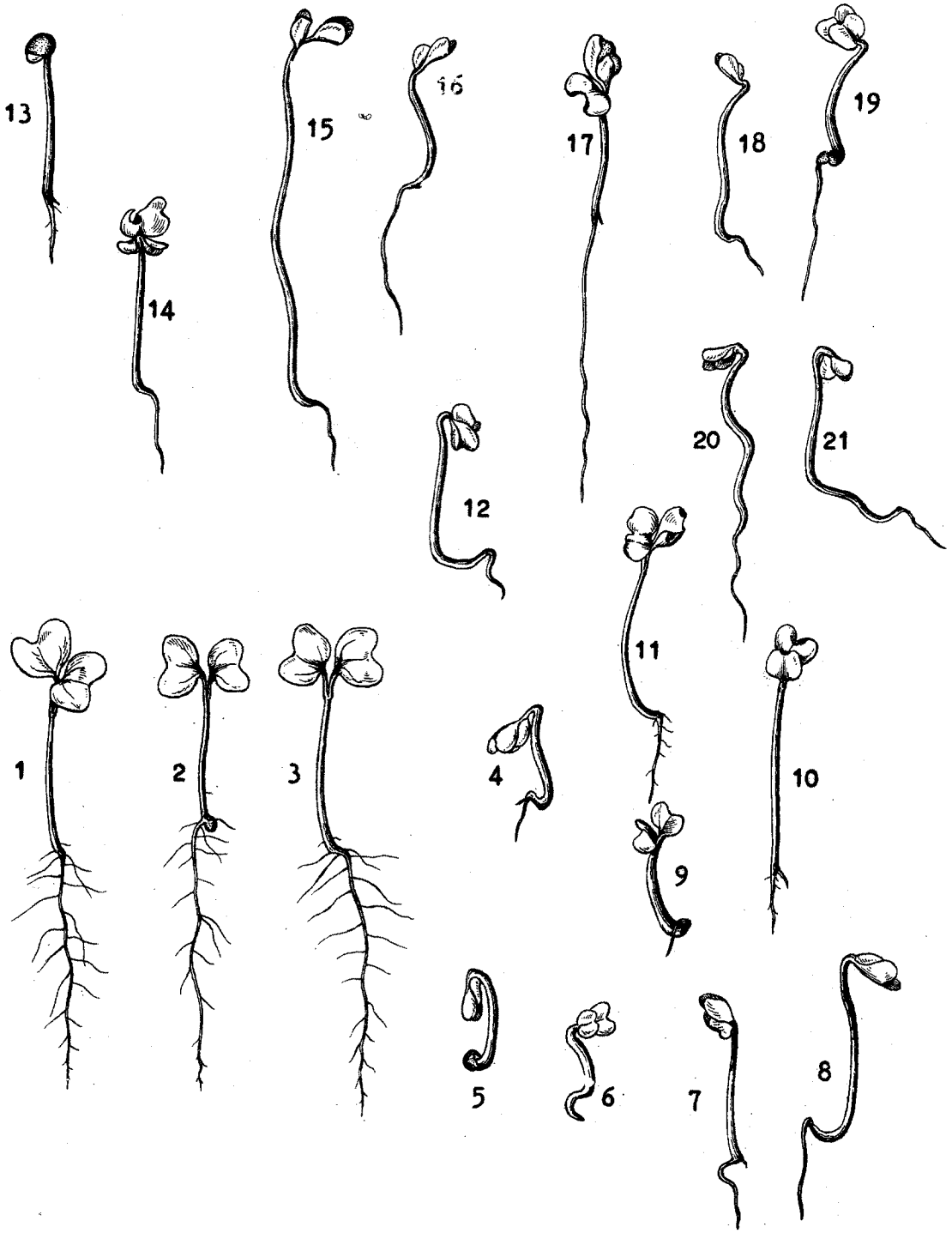
h) watery hypocotyls (usually associated with some other abnormality of the seedlings), provided this



Radish Seedlings 雜蔔幼苗

Normal （正常） —*1,2*

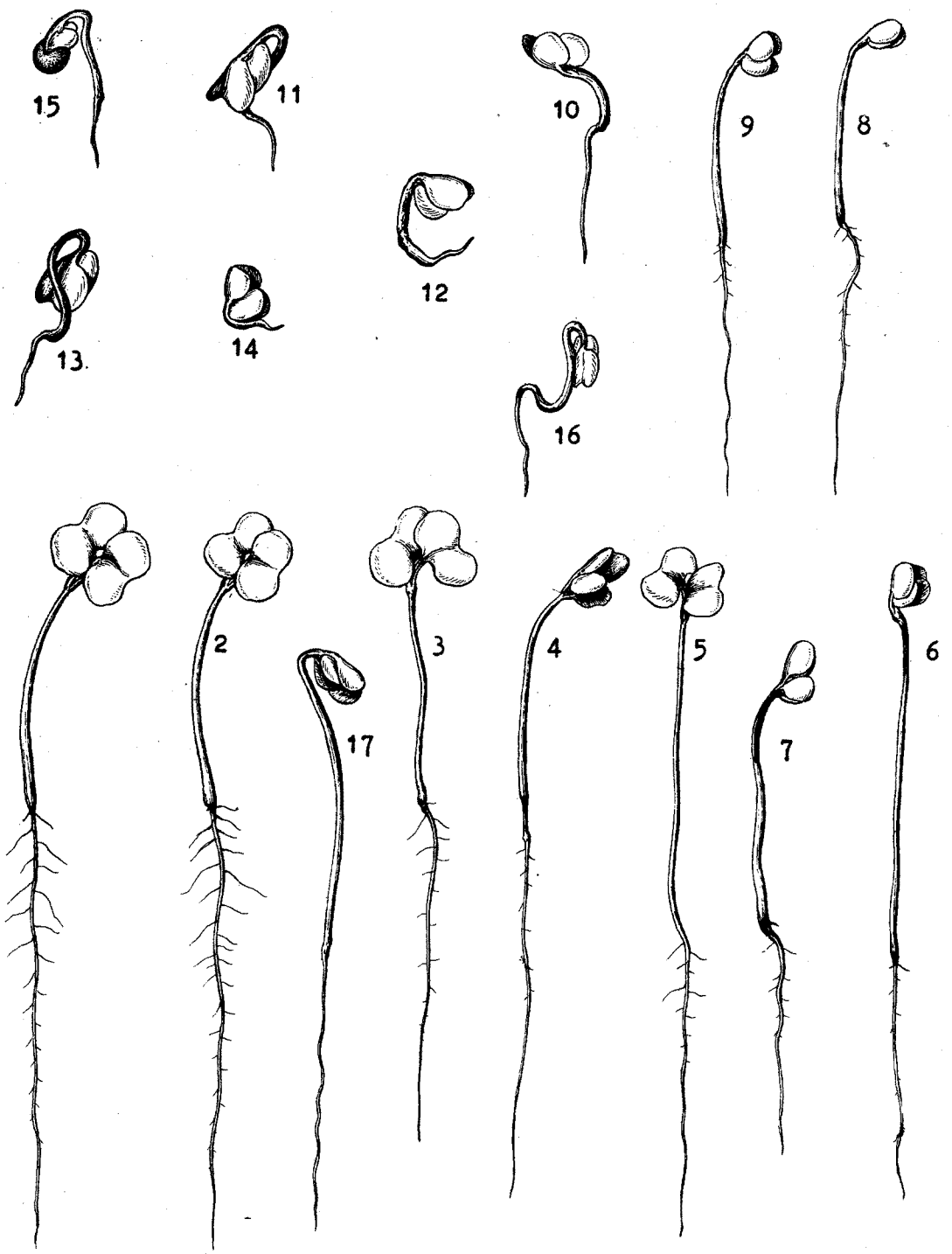
Abnormal （不正常） —*3～17*



Cauliflower *seedlings* 花椰菜幼苗

Normal (正常) —*1,2,3*

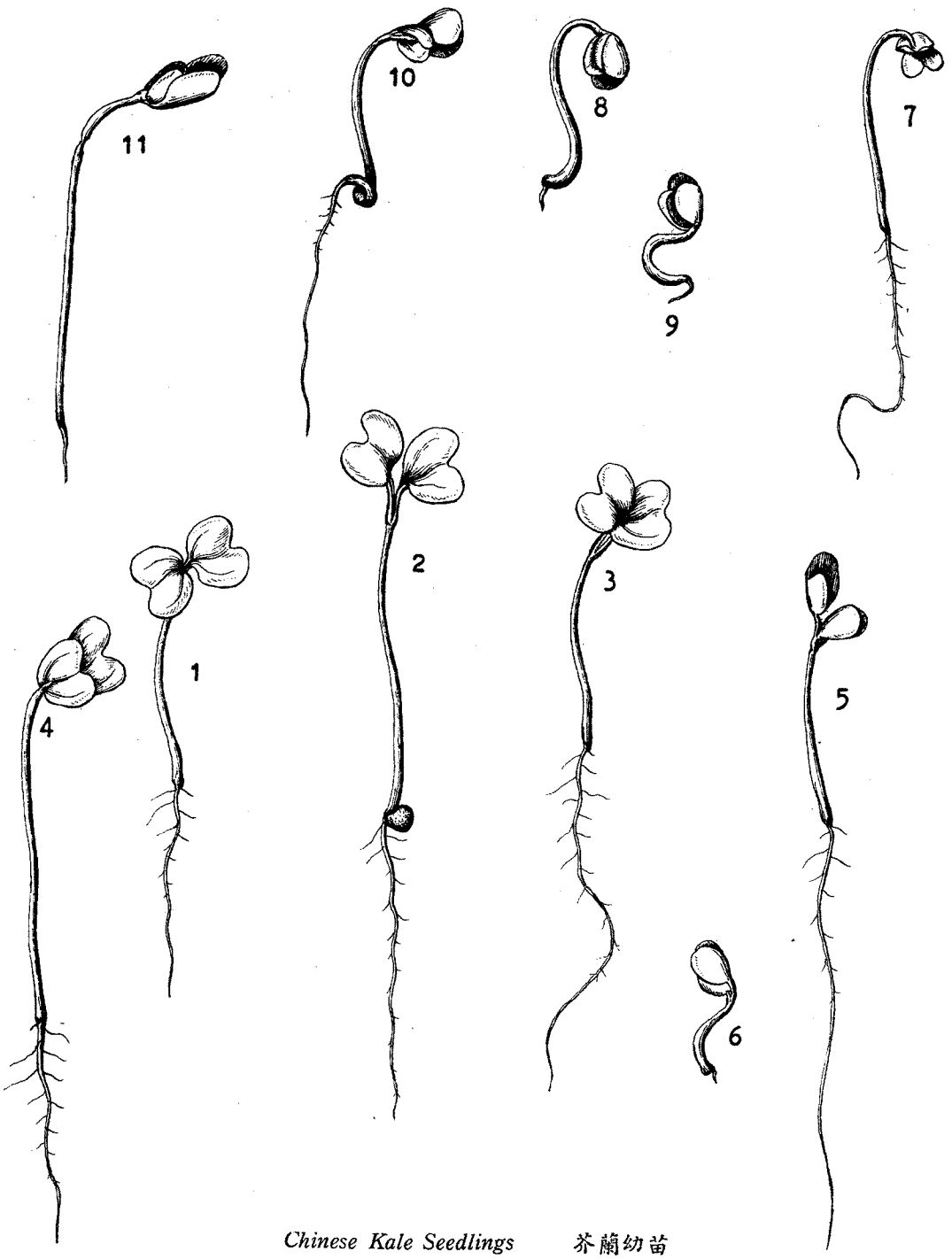
Abnormal (不正常) —*4~21*



Rape seedlings 油菜幼苗

Normal （正常） —1～5

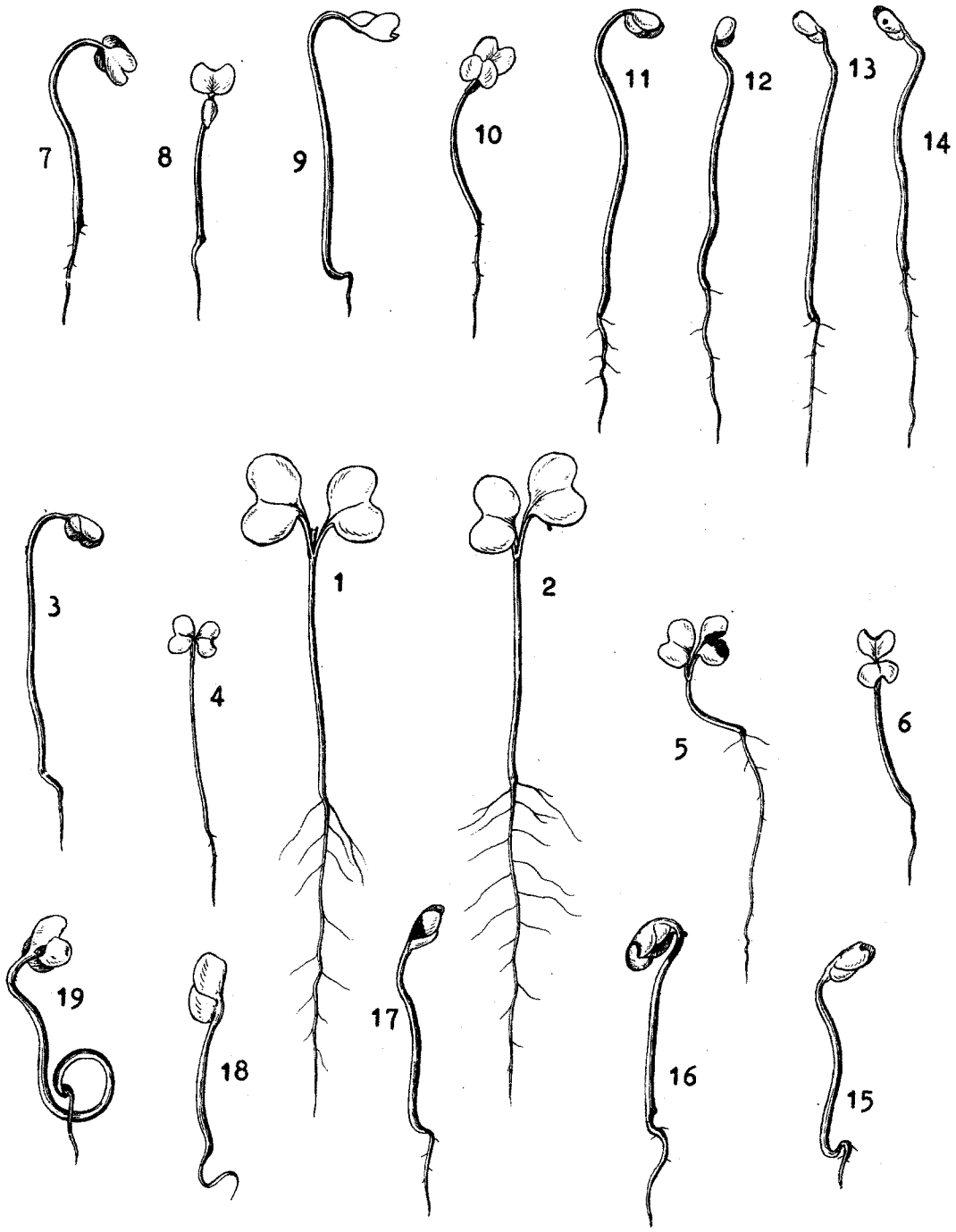
Abnormal （不正常）—6～17



Chinese Kale Seedlings 芥蘭幼苗

Normal （正常） —*1*～*4*

Abnormal （不正常） —5～11



Edible Rape Seedlings 油菜心幼苗

Normal (正常) —*1,2*

Abnormal (不正常) —*3~19*

i) various combinations of the above-named abnormalities.

D. Determination of Moisture Content

Applicable to seeds with a moisture content of 18% or lower (leguminous seeds 20% or lower) calculated on wet basis.

(A) Sending of the Sample: The sample of at least 100 grams should be shipped to the seed testing laboratory in closed, airtight, completely filled containers, so that no appreciable change in the moisture content can take place during the period between sampling and testing. The samples should be forwarded to the seed testing station without delay. The moisture tests should be conducted as soon as possible after receipt of the sample since the moisture content can change as a result of respiration of the seed.

(B) General Directions for the Various Kinds of Seed:

1. Taking the working sample: The discharge of a sample into an open mixing tray may cause a change in the moisture content and should therefore be avoided; moreover the container must never be left open. If it is not possible to stir the sample with a spoon in the original container, the sample shall be mixed by one of the following methods:
   (a) Place the opening of the original container against the opening of a similar empty container and pour the seed back and forth between the two containers until complete mixing has been attained; (b) pass the sample through a mechanical seed divider provided this can be done without exposing the sample to the air for more than 30 seconds.

2. Methods: For the purpose of moisture determination seed should be classified into one of the three following groups:

   (1) Seeds of which the moisture content should be determined at 130°C.

(2) Seeds for which the moisture cannot be determined at 130°C because of the occurrence of volatile constituents, and which therefore should be dried at 105°C.

(3) Seeds for which the 105°C method is unsuitable as consequence of extremely volatile constitutents should be tested by other methods, such as the Toluene distillation Method (For seeds of Abies spp. and Picea spp.).

3. Grinding: Some kinds of seed need to be finely or coarsely ground before drying whereas this is not, in general, necessary for small-size seeds:

(1) Thorough grinding is necessary in case of cereals, including corn, rice, sorghum, and cotton seed. The mill-setting for these kinds of seed should be so that for hard wheat at least 50% of the ground material passes through a wire screen with meshes of 0.5 mm and not more than 10% remains on a wire screen with meshes of 0.85 mm.

(2) Coarse grinding is necessary in case of large leguminous seeds such as Vicia, Phaseolus, Pisum, Lupinus, etc. The millsetting should be so that at least 50% of the ground material passes through a screen with meshes of 3.4 mm diameter.

(3) For most other kinds of seed, grinding should be omitted. It is usually best not to grind seeds of high oil content because they are difficult to grind properly and also because oxidation of the oil during drying may result in a gain in weight and thus cause errors in the moisture determination, Oil oxidation is a particularly serious consideration in seeds containing oil of high iodine number, such as flaxseed.

The quantities to be ground must be such that it is possible to carry out a moisture determination in duplicate. Weighing for determination of the moisture content must be done immediately after grinding.

(C) Methods:

1. Air-oven 130°C method:

(1) A balance with an accuracy of at least 1 mg. and weights for analytical use. Dishes of noncorrosive metal (thickness + 0.5 mm) with rounded bottom corner and a flat bottom, fitted with a cover which fits so snugly that loss of moisture is reduced to a minimum. The top of the dish must be leveled by rubbing it with an abrasive to ensure close fitting of the cover. Diameter of dish 58 mm or more, height 15-30 mm. Edge of the cover about 10 mm.

(2) An electrically heated oven (125°-140°C) with good natural ventilation and automatic temperature control of such a kind that after adjustment to 130°C the temperature in the oven remains within the limits of 130° + 3°C. The heat capacity of the oven must be such that after preheating to a temperature of 130°C followed by insertion of all the dishes, the oven will again reach a temperature of 130°C within one hour.

(3) A desiccator with blue-colored silica gel as a desiccant, preferably fitted with a thick metal plate to promote rapid cooling of the dishes. Alternatively, activated alumina may be used instead of silica gel.

(4) A grinding mill meeting the following requirements:

(a) It must be so contrived that both the product to be ground and the product ground are shut off as much as possible from the outside air during grinding.

(b) It must grind evenly and not so fast that the product is heated. Any air currents that might cause loss of moisture content must be reduced to a minimum.

(c) It must be made of a material that cannot absorb any moisture (wood is therefore not acceptable).

The determination should be done in duplicate. All weighings prescribed under this heading should be made to an accuracy of 1 mg. The dish with lid is weighed (a grams). For each duplicate, 4-5 grams of the sample is to be placed in the dish. This quantity should be evenly distributed on the whole bottom surface. The dish is covered with the closing lid and weighed (b grams). The dishes are placed in the oven on top of the lids. The oven should be heated beforehand to 130°C. In order to limit the loss of heat the dishes must be placed in the oven rapidly. From the moment that the oven has reached again the temperature of 130°C, the drying period should be 60 minutes at 130°C. After termination of the drying period the dishes are immediately covered with the lids and placed in the desiccator to cool (cooling period 30-45 minutes). The dishes with their contents and their lids are then weighed (c grams). The result is:

$$\text{Moisture content in percent} = \frac{b-c}{b-2} \times 100$$

Determinations in duplicate must not differ from each other by more than 0.2%. Should the difference be greater, the determination must be repeated in duplicate.

2. Air-oven 105°C method: The differences from the air-oven 130°C method are the following:

(1) The oven should be adjusted to 105°C ± 2°C.

(2) The length of the drying period should be 16 hours.

(3) It is recommended that the work be conducted in a laboratory with a low relative humidity of the air, because at 105°C a high relative humidity influences considerably the result of the moisture determination.

3. Toulene distillation method: For a description of this method see: Official method of Analysis of the Association of Official Agricultural Chemists, page 367, 1955 edition, published by Association of Official Agricultural Chemists, P.O. Box 540, Benjamin Franklin Station, Washington 4, D.C. (USA).

(D) Reporting the results: The moisture content should be reported to the nearest 0.1 percent. The method used should be stated in the report.

The moisture content of seed affects its quality profoundly. Dry, sound seeds can be stored for long periods with no material loss of vaibility but wet seeds are certain to deteriorate completely in a short time. Therefore, accurate methods of moisture determination are of vital importance to the seed trade.

In procedures now used to determine moisture content of seeds, the water is removed from the seeds and its amount estimated. This estimation is made by determining weight loss (oven method), volume of water removed (distillation methods), or by retaining the water in a solvent in which it is determined chemically or spectrophotometrically. For accurate results, all of the water, nothing but water, must be removed. The problem of seed moisture determination lies in removing all of the water without release of other volatiles or interfering substances and without causing chemical decomposition that may produce more water, or increase eight through oxidation.

There are four types of moisture contained in seed: (1) The most obvious water content in seed is free water and water vapor in the air spaces within the seed. (2) A second form of water is water absorbed to the inner surfaces of the seed by physical attraction. (3) In addition, there is chemically bound water, which is attached to the molecules of the seed but is still water. (4) Finally, there is water that has changed its identity; it is now combined into other molecules in the form of various compounds, such as sucrose and starch. In other words, it is no longer water, although over-heating may release it from the seed in the form of water.

Thus, when we measuring the moisture content of seed, we want only the first three kinds of water; we do not want to break down the fourth kind and release it, for it will distort the measurement of actual water in the seed.

Errors common to all methods:

1. Sampling errors: Samples for moisture determination usually are subsamples of a composite sample. How well the composite sample represents the lot depends upon the number and size of the individual portions taken, the frequency and pattern of sampling, the moisture level of the lot, and other factors. The composite and subsamples should be homogeneous but it is doubtful whether complete uniformity can be attained even with the most efficient blending possible. When seeds having different moisture contents are mixed, the moisture content of all kernels does not become the same when equilibrium conditions are reached. The possibility of sampling error is increased by the fact that every small samples (10 gm. or less) are used by most methods.

2. Grinding: In most methods determinations are made on ground seeds. Grinding introduces additional possibilities of error because heat developed in the mill during grinding may cause loss of moisture. Sair and Fetzer found that moisture losses of 0.38% and 0.57% for samples of Zea mays L. with moisture contents of 13.7% and 17.6% respectively. In the United States the Wiley mill is recommended because it produces little heat and allows minimum exposure of ground material. The basic reference method of the International Association of Cereal Chemists requires the seeds to be ground fine enough so that 90% will pass through a screen having openings of 1.42 mm. Exposure of high-moisture samples to a dry atmosphere after grinding may cause loss of moisture. The reverse effect would be found in dry samples exposed to a humid atmosphere.

In high-moisture samples, gumminess in the ground material and over-heating often occur during grinding. A few hours of preliminary drying in a warm atmosphere (approximately 40°C) is sufficient to bring the moisture content down to a satisfactory level for grinding. Obviously, weight lost in the preliminary drying must be included in calculating total moisture. The French basic reference method requires that the moisture content of cereal grains range from 10-13% when ground. In the official air-oven method (1 hr. 130°C) of the U.S. Department of Agriculture moisture content of cereal grains must be less than 16% before grinding.

3. Hysteresis: If a sample of seed comes to equilibrium with an atmosphere having a given temperature and a relative humidity, while losing moisture (desorption), the moisture content of the sample will be higher than if it reached equilibrium with the same atmosphere while gaining moisture (adsorption). This influence of a sample's previous history on its moisture content is called hysteresis. Hubbard et al, shows adsorption and desorption isotherms for wheat at 30°C. at a relative humidity of 44% the difference in moisture contents between the two isotherms is 1.6%. The hysteresis effect presumably does not produce actual errors in a given moisture determination, but frequently causes non-uniformity in a lot of seeds which, in turn, makes sampling errors more likely. It can produce confusing results and apparent errors on lots of seeds stored in the same atmosphere but having different previous histories.

E. Tolerance

When comparing two or more International Certificates based on test results obtained from the same sample or on different samples of a homegeneous seed lot, a certain variation is to be expected, regardless of whether the tests are made by the same or different stations. For

this reason it is necessary to recognize tolerances or latitudes of variation between results of tests, analyses, and examinations. It is to be distinctly understood that these tolerances are to be used only in comparing test results and they are not to be added to the test results when issuing a report or certificate. The tolerances are determined from the mean of the results being compared and applied to either the higher or lower test results. If the mean is a fraction less than 0.5 percent the fraction shall be dropped; if 0.5 percent or greater, it shall be regarded as a whole number. (For tolerance please see Tables 3-7)

F. Weight determinations

(A) Weight of 1000 seeds: For this determination, the seeds should be counted out at random from the pure seed of the air-dry sample. Four or more replicates, of one hundred seeds each, should be counted and weighed separately, in grams. The results of all replicates shall be averaged to obtain the weight of 1000 seeds. Should the difference between the figures of the two extreme series exceed the latitude allowed (6% for kinds weighing more than 25 grams per thousand and 10% for the other kinds) a retest is to be made. In case of samples which contain both hulled and unhulled seeds each series should be made up of seeds of both kinds, taken indiscriminately. The results indicating the weight of 1000 seeds should be computed to the second decimal place in grams if the weight is below 10 grams; to the first decimal place if the weight is 10 grams or more but below 25 grams, and in whole numbers if the weight exceeds 25 grams.

(B) The dry weight of 1000 seeds: This may be determined:

1. By a calculation based on the weight of 1000 seeds in conjunction with their moisture content; or

2. By weighing the seeds which have been dried to a constant weight.

(C) Volume-weight: This may be determined with the aid of a ¼ or 1 liter apparatus or some other standardized apparatus for the determination of the bushelweight. The volume weight test should be made only on samples which have been forwarded in an airtight container as described for moisture content determinations.

The figure representing the volume weight should be the average of at least two single determinations computed in kilograms per hectoliter or in English pounds per bushel, and should be given to one decimal place. A difference of 0.5 kilogram between the two weighings is permitted.

G. File Sample: The purpose to keep file sample is for future reference in case a retest is needed. The file sample should include the entire remaining portion of the seed sample or sufficient size to permit a complete retest. The file sample is preferably to be packed a moisture proof bag, marked with the laboratory number and stored in a cold storage room for at least one year. There is no need to keep the file sample longer than one year unless the sample is involved in case of official or civil action, then it should be retained until the case is terminated.

It is advisable to place a small quantity of insecticides in samples suspected of being infested with insects. All seed testing laboratories should have ample space and facilities to provide the most favorable storage conditions.

H. Care of samples by the laboratory:

The large number of seed samples ordinary received by a laboratory during a testing season necessitates care in: (1) retaining the identity of each sample received; (2) avoiding damage by rodents or insects; and (3) avoiding exposure to extreme variations in temperature and moisture.

Seed samples received by a laboratory should be unpacked as soon as possible and should be given a record number so that they may be readily located and referred to when necessary. A recording card is usually assigned to each sample. For the sake of convenience,

paper bags which when loaded can stand on one end can be used. After unpacking of the seed samples. The numbers of the samples can be tested in one day should be carefully figured and managed. The determination of moisture contents of the seed samples should be done as soon as possible after the sample is received and registered within the day.

Proper care should be taken to the samples awaiting testing to avoid damages by rodents, admixing with other seed samples and any other possible incidents which might cause the change of property of the original seed sample.

Table I. - Weights for Working Samples

Name of Seed	Minimum weight for purity analysis	Minimum wgt. for noxious-weed seed examination	Approximate number of seeds per gram	Approximate number of seeds per ounce
Agricultural Seed	Grams	Grams	Number	Number
Alfalfa - Medicago sativa	5	50	500	14,175
Alfileria - Erodium cicutarium	5	50	441	15,364
Bahia grass - Paspalum notatum				
Var. Pensacola	5	50	---	---
All other varieties	10	50	366	10,376
Barley - Hordeum vulgare	100	500	30	851
Bean:				
Adzuki - Phaseolus angularis	500	500	11	312
Field - Phaseolus vulgaris	500	500	4	113
Mung - Phaseolus aureus	100	500	24	680
Velvet - Stizolobium deeringianum	500	500	2	57
Beet, field and sugar - Beta vulgaris	50	300	54	1,531
Beggarweed, Florida - Desmodium tortuosum	5	50	442	12,541
Bentgrass:				
Astoria - Agrostis tenuds	1/2	25	12,048	341,560
Creeping - Agrostis palustris	1/2	25	17,196	487,521
Colonial - Agrostis tenuis	1/2	25	19,231	545,199
Highland - Agrostis tenuis	1/2	25	20,000	567,000
Velvet - Agrostis canina	1/2	25	23,810	675,014
Bermuda grass - Cynodon dactylon	1	25	3,940	111,699
Bluegrass:				
Annual - Poa annua	1	25	2,636	74,731
Bulbous - Poa bulbosa	2	35	1,020	28,968
Canada - Poa compressa	1	25	5,500	155,925
Kentucky (including var. Merion) - Poa pratensis	1	25	4,800	136,080
Nevada - Poa nevadensis	1	25	2,304	65,434
Rough - Poa trivialis	1	25	5,600	158,760
Texas - Poa arachnifera	1	25	2,500	71,000
Wood - Poa nemoralis	1	25	7,097	201,200
Bluestem:				
Big - Andropogon gerardi (A. furcatus)	10	50	336	9,542
Little - Andropogon scoparius	5	50	560	15,904
Sand - Andropogon hallii	10	50	233	6,617
Yellow - Andropogon ischaemum	2	35	---	---
Brome:				
Field - Bromus arvensis	5	50	431	12,244
Mountain - Bromus marginatus	25	150	141	4,004
Smooth - Bromus inermis	5	50	300	8,505
Broomcorn - Sorghum vulgare var. technicum	50	300	60	1,704

Table I. - Weights for Working Samples (Cont.)

Name of Seed	Minimum weight for purity analysis	Minimum wgt. for noxious-weed seed examination	Approximate number of seeds per gram	Approximate number of seeds per ounce
Buckwheat - Fagopyrum esculentum	50	300	45	1,276
Buffalo grass - Buchloe dactyloides				
(Burs)	50	300	110	3,124
(Caryopses)	2	35	738	20,959
Buffelgrass - Pennisetum ciliare				
(Fascicles)	5	50	460	13,064
(Caryopses)	2	35	1,940	55,096
Burnet, little - Sanguisorba minor	25	150	108	3,068
Canary grass - Phalaris canariensis	25	150	150	4,254
Canary grass, reed - Phalaris arundinacea	2	35	1,200	34,020
Carpet grass - Axonopus affinis	1	25	2,475	70,166
Castorbean - Ricinus communis	500	500	5	142
Chess, soft - Bromus mollis	5	50	554	15,739
Chickpea - Cicer arietinum	500	500	2	57
Clovers:				
Alsike - Trifolium hybridum	2	35	1,500	42,525
Alyce - Alysicarpus vaginalis	5	50	664	18,824
Berseem - Trifolium alexandrinum	5	50	456	12,928
Bur, California - Medicago hispida				
(In bur)	50	300	---	---
(Out of bur)	10	50	375	10,650
Bur, spotted - Medicago arabica				
(In bur)	50	300	49	1,389
(Out of bur)	10	50	550	15,620
Button - Medicago orbicularis	10	50	337	9,554
Cluster - Trifolium glomeratum	1	25	2,924	82,895
Crimson - Trifolium incarnatum	10	50	330	9,356
Ladino - Trifolium repens	2	35	1,937	55,010
Lappa - Trifolium lappaceum	2	35	1,500	42,525
Large hop - Trifolium procumbens (T. campestre)	1	25	5,434	154,326
Persian - Trifolium resupinatum	2	35	1,416	40,144
Red - Trifolium pratense	5	50	600	17,010
Rose - Trifolium hirtum	5	50	358	10,279
Sour - Melilotus indica	5	50	662	18,768
Strawberry - Trifolium fragiferum	5	50	635	18,002
Sub - Trifolium subterraneum	25	150	119	3,374
Suckling or small hop - Trifolium dubium	2	35	1,948	55,226
Sweet:				
White - Melilotus alba	5	50	570	16,160
Yellow - Melilotus officinalis	5	50	570	16,160
White - Trifolium repens	2	35	1,500	42,525

Table I. - Weights for Working Samples (Cont.)

Name of Seed	Minimum weight for purity analysis	Minimum wgt. for noxious weed seed examination	Approximate number of seeds per gram	Approximate number of seeds per ounce
Corn:				
Field - Zea mays	500	500	3	85
Pop - Zea mays var. everta	500	500	---	---
Cotton - Gossypium spp.	500	500	8	227
Cowpea - Vigna sinensis	500	500	8	227
Crested dogtail - Cynosurus cristatus	2	35	1,900	53,865
Crotalaria:				
Crotalaria intermedia	10	50	207	5,878
Crotalaria juncea	100	500	36	1,022
Crotalaria lanceolata	10	50	375	10,650
Crotalaria spectabilis	25	150	80	2,268
Crotalaria striata	10	50	215	6,106
Crownvetch - Coronilla varia	10	50	304	8,637
Dallis grass - Paspalum dilatatum	2 1/	35	592	16,795
Dichondra - Dichondra repens	5	50	472	13,409
Dropseed, sand - Sporobolus cryptandrus	1/2	25	11,927	338,727
Fescue:				
Chewings - Festuca rubra var. commutata	2	35	1,200	34,120
Hair - Festuca capillata	1	25	3,200	90,720
Meadow - Festuca elatior	5	50	500	14,175
Red - Festuca rubra	2	35	1,200	34,120
Sheep - Festuca ovina	2	35	1,167	33,143
Tall - Festuca arundinacea	5	50	500	14,175
Flax - Linum usitatissimum	15	100	178	5,046
Grama:				
Blue - Bouteloua gracilis	2	35	1,977	56,147
Side-oats - Bouteloua curtipendula				
(Other than caryopses)	5	50	422	11,985
(Caryopses)	2	35	1,607	45,639
Guar - Cyamopsis tetragonoloba	100	500	34	966
Guinea grass - Panicum maximum	5	50	2,207	62,540
Harding grass - Phalaris tuberosa var. stenoptera	5	50	750	21,300
Hemp - Cannabis sativa	50	300	46	1,304
Indian grass, yellow - Sorghastrum nutans	10	50	364	10,338
Indigo, hairy - Indigofera hirsuta	10	50	437	12,382
Japanese lawngrass - Zoysia japonica	2	35	3,012	85,541
Johnson grass - Sorghum halepense	10	50	290	8,222
Kenaf - Hibiscus cannabinus	50	300	---	---
Kudzu - Pueraria thunbergiana	25	150	81	2,296
Lentil - Lens culinaris	50	300	42	1,193

Table I. - Weights for Working Samples (Cont.)

Name of Seed	Minimum weight for purity analysis	Minimum wgt. for noxious weed seed examination	Approximate number of seeds per gram	Approximate number of seeds per ounce
Lespedeza:				
Sericea or Chinese - Lespedeza cuneata (L. sericea)	5	50	820	23,248
Korean - Lespedeza stipulacea	5	50	525	14,884
Siberian - Lespedeza hedysaroides	5	50	820	23,288
Striate (Common, Kobe, Tenn. 76) - Lespedeza striata	5	50	750	21,263
Lovegrass, sand - Eragrostis trichodes	1	25	3,550	100,856
Lovegrass, weeping - Eragrostis curvula	1	25	3,282	93,208
Lupine:				
Blue - Lupinus angustifolius	500	500	7	198
White - Lupinus albus	500	500	7	198
Yellow - Lupinus luteus	500	500	9	225
Manila grass - Zoysia matrella	2	35	---	---
Meadow foxtail - Alopecurus pratensis	2	35	1,200	34,020
Medick, black - Medicago lupulina	5	50	586	16,613
Millet:				
Browntop - Panicum ramosum	10	50	303	8,590
Foxtail, German, Hungarian, Golden or Siberian - Setaria italica	5	50	470	13,325
Japanese - Echinochloa crusgalli var. frumentacea	10	50	320	9,072
Pearl - Pennisetum glaucum	25	150	194	5,500
Proso - Panicum milliaceum	25	150	180	5,103
Molasses grass - Melinis minutiflora	1	25	15,000	425,250
Mustard:				
Black - Brassica nigra	5	50	1,256	35,608
White - Brassica hirta	25	150	162	4,593
Napier grass - Pennisetum purpureum	5	50	---	---
Oats - Avena sativa and A. byzantina	100	500	35-50	1000-1425
Oatgrass, tall meadow - Arrhenatherum elatius	5	50	330	9,356
Orchard grass - Dactylis glomerata	2	35	1,441	40,852

Table I. - Weights for Working Samples (Cont.)

Name of Seed	Minimum weight for purity analysis	Minimum wgt. for noxious weed seed examination	Approximate number of seeds per gram	Approximate number of seeds per ounce
Panic grass, blue - Panicum antidotale	2	35	1,448	41,123
Peanut - Arachis hyogaea	500	500	1--3	---
Peas, field - Pisum sativum var. arvense	500	500	4	113
Rape:				
Annual - Brassica napus var. annua	10	50	346	9,809
Bird - Brassica campestris	10	50	425	12,049
Turnip - Brassica campestris vars.	10	50	536	15,196
Winter - Brassica napus var. biennis	10	50	230	6,521
Redtop - Agrostis alba	1/2	25	11,000	311,850
Rescue grass - Bromus catharticus	25	150	144	4,089
Rhodes grass - Chloris gayana	1	25	4,724	133,925
Rice - Oryza sativa	100	500	66	1,871
Ricegrass, Indian - Oryzopsis hymenoides	10	50	308	8,747
Rough pea - Lathyrus hirsutus	100	500	39	1,095
Rye - Secale cereale	100	500	40	1,134
Ryegrass:				
Italian - Lolium multiflorum	5	50	500	14,175
Perennial - Lolium perenne	5	50	500	14,175
Safflower - Carthamus tinctorius	100	500	29	824
Sainfoin - Onobrychis viciaefolia	50	500	50	1,418
Seeame - Sesamum orientalo	10	50	360	10,206
Sesbania - Sesbania exaltata	25	150	105	2,982
Smilo - Oryzopsis miliacea	2	35	2,008	57,027
Sorghum almum - sorghum almum	25	150	159	---
Sorghum:				
(Grain and Sweet) - Sorghum vulgare	50	300	50-55	1,418-1,559
Sorgrass 2/	25	150	159	4,517
Soybean - Glycine max	500	500	6-13	175-435
Sudan grass - Sorghum sudanense	25	150	120	3,402
Sunflower (Cult.) - Helianthus annuus	100	500	---	---
Sweet vernal grass - Anthoxanthum odoratum	2	35	1,600	45,360
Switch grass - Panicum virgatum	5	50	814	23,117
Timothy - Phleum pratense	2	35	2,500	70,875
Tobacco - Nicotiana tabacum	1/2	25	15,625	442,969
Trefoil, big - Lotus uliginosus (L. major)	2	35	1,944	55,209
Trefoil, birdsfoot - Lotus corniculatus	2	35	814	23,117
Vasey grass - Paspalum urvillei	2	35	970	27,548
Veldtgrass - Erharta calycina	2	35	655	18,609
Velvetgrass - Holcus lanatus	1	25	3,359	95,060

Table I. - Weights for Working Samples (Cont.)

Name of Seed	Minimum weight for purity analysis	Minimum wgt. for noxious weed seed examination	Approximate number of seeds per gram	Approximate number of seeds per ounce
Vetch:				
Common - Vicia sativa	100	500	19	539
Hairy - Vicia villosa	100	500	36	1,021
Hungarian - Vicia pannonica	100	500	24	680
Monantha - Vicia articulata	100	500	---	---
Narrowleaf - Vicia angustifolia	50	300	60	1,701
Purple - Vicia atropurpurea	100	500	22	624
Woollypod - Vicia dasycarpa	100	500	25	709
Wheat: Common, spelt, emmer, durum, club, Polish - Triticum spp.	100	500	25	709
Wheatgrass:				
Crested, fairway - Agropyron cristatum	5	50	714	20,242
Crested, standard - Agropyron desertorum	5	50	425	12,049
Hairy intermediate - Agropyron tricophroum	10	50	180	5,102
Intermediate - Agropyron intermedium	10	50	230	6,519
Slender - Agropyron trachycaulum	10	50	340	9,639
Tall - Agropyron elongatum	10	50	140	3,968
Western - Agropyron smithii	10	50	235	6,662
Wild-rye:				
Canada - Elymus canadensis	10	50	261	7,412
Russian - Elymus junceus	5	50	400	11,364
Vegetable and Herb Seed				
Artichoke - Cynara scolymus	100	500	24	680
Asparagus - Asparagus officinalis	100	500	25	709
Beans:				
Asparagus - Vigna sesquipedalis	100	500	8	227
Garden - Phaseolus vulgaris	500	500	4	113
Horse or broad - Vicia faba	500	500	---	---
Lima - Phaseolus lunatus var. macrocarpus	500	500	2	57
Runner - Phaseolus coccineus	500	500	1	---
Beet - Beta vulgaris	50	300	58	1,644
Broccoli - Brassica oleracea var. botrytis	10	50	315	8,930
Brussels sprouts - Brassica oleracea var. gemmifera	10	50	315	8,930

Table I. - Weights for Working Samples (Cont.)

Name of Seed	Minimum weight for purity analysis	Minimum wgt. for noxious weed seed examination	Approximate number of seeds per gram	Approximate number of seeds per ounce
Cabbage - Brassica oleracea var. capitata	10	50	315	8,930
Cardoon - Cynara cardunculus	100	500	---	---
Carrot - Daucus carota	5	50	826	23,417
Cauliflower - Brassica oleracea var. botrytis	10	50	315	8,930
Celeriac - Apium graveolens var. rapaceum	1	25	2,521	71,470
Celery - Apium graveolens var. dulce	1	25	2,521	71,470
Chicory - Cichorium intybus	5	50	940	26,649
Citron - Citrullus vulgaris	500	500	11	312
Collards - Brassica oleracea var. acephala	10	50	315	8,930
Corn, sweet - Zea mays	500	500	---	---
Cornsalad - (Fetticus) Valerianella locusta var. olitoria				
Vars. Full Hearted and Dark Green Full Hearted	5	50	---	---
All other varieties	10	50	380	10,773
Cowpea - Vigna sinensis	500	500	8	227
Cress:				
Garden - Lepidium sativum	5	50	424	12,020
Water - Rorippa nasturtium - aquaticum	1	25	5,172	146,626
Cucumber - Cucumis sativus	100	500	38	1,077
Dandelion - Taraxacum officinale	2	35	1,240	35,154
Dill - Anethum graveolens	5	50	800	22,720
Eggplant - Solanum melongena	10	50	228	6,464
Endive - Cichorium endivia	5	50	940	26,649
Kale 3/ - Brassica oleracea var. acephala	10	50	315	8,930
Kale, Chinese - Brassica oleracea var. alboglabra	10	50	---	---
Kohlrabi - Brassica oleracea var. gongylodes	10	50	315	8,930
Leek - Allium porrum	10	50	396	11,227
Lettuce - Lactuca sativa	5	50	888	25,175
Muskmelon - Cucumis melo	100	500	45	1,276
Mustard:				
India - Brassica juncea	5	50	624	17,690
Spinach - Brassica perviridis	5	50	536	15,196
Okra - Hibiscus escelentus	100	500	19	539
Onion - Allium cepa	10	50	341	9,667
Pak-choi - Brassica chinensis	5	50	633	17,946
Parsley - Petroselinum hortense (P. crispum)	5	50	648	18,371

Table I. - Weights for Working Samples (Cont.)

Name of Seed	Minimum weight for purity analysis	Minimum wgt. for noxious weed seed examination	Approximate number of seeds per gram	Approximate number of seeds per ounce
Parsnip - Pastinaca sativa	10	50	429	12,162
Peas, garden - Pisum sativum	500	500	3	85
Pepper - Capsicum spp.	25	150	167	4,734
Pe-tsai (Chinese cabbage) - Brassica pekinensis	5	50	633	17,946
Pumpkin - Cucurbita pepo	500	500	5	113
Radish - Raphanus sativus	50	300	75	2,126
Rhubarb - Rheum rhaponticum	50	300	60	1,701
Rutabaga - Brassica napus var. napobrassica	10	50	428	12,134
Sage - Salvia officinalis	25	150	120	3,436
Salsify - Tragopogon porrifolius	50	300	66	1,871
Savory - Satureja hortensis	2	35	1,750	49,700
Sorrel - Rumex acetosa	2	35	1,079	30,590
Soybean - Glycine max	500	500	6-13	175-435
Spinach:				
Common - Spinacia oleracea	25	150	100	2,835
New Zealand - Tetragonia expansa	100	500	13	369
Squash - Cucurbita moschata and C. maxima	500	500	14	397
Swiss chard - Beta vulgaris var. cicla	50	300	58	1,644
Tomato:				
Common - Lycopersicon esculentum	5	50	405	11,482
Husk - Physalis pubescens	2	35	1,240	35,154
Turnip - Brassica rapa	10	50	536	15,196
Watermelon - Citrullus vulgaris	500	500	11	312

1/ If the purity separation of Dallis grass yields less than 400 seeds a duplicate analysis shall be made and the results shall be calculated on the basis of 4 grams.

2/ Rhizomatous derivatives of a Johnsongrass x sorghum cross or a Johnson grass x Sudan grass cross.

3/ Includes the kales which are varieties of Brassica napus.

Table 2.

Methods of Testing for Laboratory Germination and Hard Seed

Kind of Seed	Substrata	Temperature °C	First Count Days	Final Count Days	Additional Directions
Alfalfa--Medicago sativa	B,T,S	20	4	7[1/]	
Alfileria--Erodium cicutarium	B,T	20-30	3	14	Clip seeds.
Bahia grass-Paspalum notatum					
Var. Pensacola	P,S	20-35	7	28[2/]	Light;
All other vars.	P	30-35	3	21	Light; remove glumes; Scratch caryopses; KNO_3
Barley--Hordeum vulgare	B,T,S	20,15	4	7	Prechill 5 days at 5° or 10°C.
Bean:					
Adzuki--Phaseolus angularis	B,T,S	20-30	4	10[1/]	
Field--Phaseolus vulgaris	B,T,S	20-30;25	5	8[1/]	
Mung--Phaseolus aureus	B,T,S	20-30	3	7[1/]	
Velvet--Stizolobium deeringianum	BT,S,C	20-30	3	14[1/]	
Beet--Beta vulgaris					
Field	B,T,S	20-30	3	14	
Sugar	B,T,S	20-30;20	3	10	
Beggarweed, Florida--Desmodium tortuosum	B,T	30	5	28[1/]	
Bentgrass:					
Colonial, Astoria, Highland--Agrostis tenuis	P	15-30;10-30	7	28	Light; KNO_3 Prechill at 5° or 10°C for 7 days.
Creeping (seaside)--Agrostis palustris	P	15-30;10-30	7	28	Light; KNO_3 Prechill at 5° or 10°C for 7 days.
Velvet--Agrostis canina	P	20-30	7	21	Light; KNO_3
Bermuda grass--Cynodon dactylon	P	20-35	7	21	Light; KNO_3
Bluegrass:					
Annual--Poa annua	P	20-30	7	21	Light
Bulbous--Poa bulbosa	P,S	10	10	35	KNO_3 or soil. Prechill all samples at 5°C. for 7 days.
Canada--Poa compressa	P	15-30	10	28	Light; KNO_3 10-30°C. and KNO_3.
Kentucky (including var. Merion)--Poa pratensis	P	15-30;10-30	10	28	Light; KNO_3 Prechill at 10°C for 5 days.

See footnotes at end of table.

Table 2 (Cont'd)

Kind of Seed	Substrata	Temperature °C	First Count Days	Final Count Days	Additional Directions
Nevada--Poa nevadensis	P	20-30	7	21	Light; KNO_3
Rough--Poa trivialis	P	20-30	7	21	Light
Texas--Poa arachnifera	P	20-30	7	28	Light; KNO_3. Prechill at 5°C. for 2 weeks.
Wood--Poa nemoralis	P	20-30	7	28	Light.
Bluestem:					
Big--Andropogon gerardi (A. furcatus)	P,TS	20-30	7	28	Light; KNO_3. Prechill at 5°C. for 2 weeks
Little--Andropogon scoparius	P,TS	20-30	7	28	Do.
Sand--Andropogon hallii	P,TS	20-30	7	28	Do.
Yellow--Andropogon ischaemum	P,TS	20-30	5	21	Do.
Brome:					
Field--Bromus arvensis	TB,P	20-30;15-25	6	14	Light. Prechill at 10°C. for 5 days.
Mountain--Bromus marginatus	P	20-30	6	14	Light
Smooth--Bromus inermis	P,B,TB	20-30	6	14	Light optional. Prechill at 5° or 10°C. for 5 days, then test at 30°C for 9 additional days.
Broomcorn--Sorghum vulgare var. technicum	T,B,S	20-30	3	10	
Buckwheat--Fagopyrum esculentum	B,T	20-30	3	6	
Buffalo grass-Buchloe dactyloides					
(Burs)	P,TB,TS	20-35	7	28	Light; KNO_3. Prechill at 5°C. for 6 weeks;
(Caryopses)	P	20-35	5	14	test 14 additional days.
Buffelgrass--Pennisetum ciliare	S	30	7	28	Light; press fascicles into well packed soil and prechill at 5°C. for 7 days.
Burnet, little--Sanguisorba minor	B,T	15	5	14	
Canary grass--Phalaris canariensis	B,T	20-30	3	7	
Canary grass, reed--Phalaris arundinacea	P	20-30	5	21	Light; KNO_3
Carpet grass--Axonopus affinis	P	20-35	10	21	Light. KNO_3
Castorbean--Ricinus communis	T,S	20-30	7	14	Remove caruncle if mold interferes with test.

Table 2 (Cont'd)

Kind of Seed	Substrata	Temperature °C	First count Days	Final count Days	Additional Directions
Chess, soft--Bromus mollis	P	20-30	7	14	Light. Prechill at 5° or 10°C.for 7 days.
Chickpea--Cicer arietinum	T,S	20-30	3	7	
Clovers:					
Alsike--Trifolium hybridum	B,T,S	20	3	7 1/	15°C
Alyce--Alysicarpus vaginalis	B,T	35	4	21 1/	
Berseem-Trifolium alexandrinum	B,T,S	20	3	7 1/	15°C.
Bur, California--Medicago hispida	B,T	20	4	14 1/	Remove seeds from bur
Bur, spotted--Medicago arabica	B,T	20	4	14 1/	Do.
Button--Medicago orbicularis	B,T	20	4	10 1/	15°C
Cluster--Trifolium glomeratum	B,T	20	4	10 1/	15°C
Crimson--Trifolium incarnatum	B,T,S	20	4	7 1/	Do.
Ladino--Trifolium repens	B,T,S	20	3	7 1/	Do.
Lappa--Trifolium lappaceum	B,T	20	3	7 1/	Do.
Large hop--Trifolium procumbens (T. campestre)	B,T	20	4	14 1/	Do.
Persian--Trifolium resupinatum	B,T	20	3	7 1/	Do.
Red--Trifolium pratense	T,B,S	20	4	7 1/	Do.
Rose--Trifolium hirtum	B,T	20	4	10 1/	Do.
Sour--Melilotus indica	B,T	20	3	14 1/	
Strawberry--Trifolium fragiferum	B,T	20	3	7 1/	Do.
Sub--Trifolium subterraneum	B,T	20	4	14 1/	Do.
Suckling (small hop)--Trifolium dubium	B,T	20	4	14 1/	Do.
Sweet--Melilotus alba and M. officinalis	B,T,S	20	4	7 1/	
White--Trifolium repens	B,T,S	20	3	7 1/	15°C
Corn:					
Field--Zea mays	B,T,S	20-30;25	4	7	
Pop--Zea mays var.everta	B,T,S	20-30;25	4	7	
Cotton--Gossypium spp.	B,T,S	20-30	4	12 1/	Test by alternate metho
Cowpea--Vigna sinensis	B,T,S	20-30	5	8 1/	
Crested dogtail--Cynosurus cristatus	P	20-30	10	21	Light. Prechill for 3 days at 5° or 10°C.

Table 2 (Cont'd)

Kind of Seed	Substrata	Temperature °C	First Count Days	Final Count Days	Additional Directions
Crotalaria--Crotalaria intermedia, C. juncea, C. lanceolata, C. spectabilis and C. striata	T,B,S	20-30	4	10[1/]	
Crownvetch--Coronilla varia	B,T,S	20	7	14[1/]	
Dallis grass-Paspalum dilatatum	P	20-35	7	21	Light; KNO_3
Dichondra--Dichondra repens	B,T	20-30	7	28[1/]	
Dropseed, sand--Sporobolus cryptandrus	P	15-35	5	42	Light; KNO_3. Prechill at 5°C. for 4 to 8 weeks and test for 28 days.
Fescue:					
Chewings--Festuca rubra var.commutata	P	15-25	7	21	Light and KNO_3 optional. Prechill at 5° or 10°C. for 5 days.
Alternate method	P	20-30	7	28	Do.
Hair--Festuca capillata	P	10-25	10	28	KNO_3
Meadow--Festuca elatior	P	20-30; 15-25	5	14	Light and KNO_3 optional
Red--Festuca rubra	P	15-25	7	21	Do. Prechill at 5° or 10°C. for 5 days.
Alternate method	P	20-30	7	28	Do.
Sheep--Festuca ovina	P	15-25	7	21	
Alternate method	P	20-30	7	28	Light.
Tall--Festuca arundinacea	P	20-30	5	14	Light and KNO_3 opetional. Prechill at 5° or 10°C. for 5 days and extend test to 21 days.
Alternate method	P	15-25	5	14	Do.
Flax--Linum usitatissimum	B,T,S	20-30	3	7	
Grama:					
Blue--Bouteloua gracilis	P,TB	20-30	7	28	Light. KNO_3
Side-oats--Bouteloua curtipendula	P	15-30	7	28	Light; KNO_3
Guar--Cyamopsis tetragonoloba	B,T,S	30; 20-30	5	14[1/]	
Guinea grass--Panicum maximum	P	15-35	10	28	Light; KNO_3 opetional.
Harding grass--Phalaris tuberosa var. stenoptera	P	10-30	7	28	Light. KNO_3

Table 2 (Cont'd)

Kind of Seed	Substrata	Temperature °C	First Count Days	Final Count Days	Additional Directions
Hemp--Cannabis sativa	B,T	20-30	3	7	
Indiangrass, yellow--Sorghastrum nutans	P,TS	20-30	7	28	Light; KNO_3. Prechill at 5°C. for 2 weeks.
Indigo, hairy--Indigofera airsuta	B,T	20-30	5	14[1/]	
Japanese lawngrass--Zoysia japonica	P	35-20	10	28	Light. KNO_3.
Johnson grass-Sorghum halepense	P	20-35	7	35[2/]	Do
Kenaf--Hibiscus cannabinus	T,B	20-30	4	8	
Kudzu--Pueraria thunbergiana	T,B	20-30	5	14[1/]	
Lentil--Lens culinaris	B,T	20	5	10[1/]	
Lespedeza:					
Korean--Lespedeza stipulacea	T,B,S	20-35	5	14[1/]	
Sericea or Chinese--Lespedeza cuneata(L.sericea)	T,B,S	20-35	7	21[1/]	
Siberian--Lespedeza hedysaroides	T,B,S	20-35	7	21[1/]	
Striate (Common, Kobe, Tenn. 76)--Lespedeza striata	T,B,S	20-35	7	14[1/]	
Lovegrass, sand--Eragrostis trichodes	P	20-30	5	14	Light; KNO_3. Prechill at 5° or 10°C. for 6 weeks.
Lovegrass, weeping--Eragrostis curvula	P	20-35	5	14	Light. KNO_3
Lupine:					
Blue--Lupinus angustifolius	B,T,S	20	4	10[1/]	
White--Lupinus albus	B,T	20	3	10[1/]	
Yellow--Lupinus luteus	B,T	20	7	10[1/]	
Manila grass--Zoysia matreila	P	35-20	10	28	Do.
Meadow foxtail--Alopecurus pratensis	P	20-30	7	14	Light
Medick, black--Medicago lupulina	T,B,S	20	4	7[1/]	
Millet:					
Browntop--Panicum ramosum	B,P	20-30	4	14	Light; KNO_3 optional. Predry at 35-40°C. for 7 days; or test at 30°C

Table 2 (Cont'd)

Kind of Seed	Substrata	Temperature °C	First Count Days	Final Count Days	Additional Directions
Foxtail--Such as common, German, Hungarian, Siberian, or golden--Setaria italica	B,T	20-30; 15-30	4	10	
Japanese--Echinochloa crus-galli var. frumentacea	B,T	20-30	4	10	
Pearl--Pennisetum glaucum	B,T	20-30	3	7	
Proso--Panicum miliaceum	B,T	20-30	3	7	
Molasses grass--Melinis minutiflora	P	20-30	7	21	Light.
Mustard:					
Black--Brassica nigra	P	20-30	3	7	Light. KNO_3 and prechill at 10°C. for 3 days.
White--Brassica hirta	P	20-30	3	5	Light.
Napier grass--Pennisetum purpureum	B,T	20-30	3	10	
Oats--Avena sativa and A. byzantina	B,T,S	20;15	5	10	Prechill at 5° or 10°C. for 5 days and conclude test on 7th day.
Oatgrass, tall--Arrhenatherum elatius	P	20-30	6	14	Light
Orchard grass--Dactylis glomerata	P,TS	20-30	7	21	Light; germination more rapid on soil.
Panic grass, blue--Panicum antidotale	P,TS	20-30	7	28	
Peanut--Arachis hypogaea	B,T,S	20-30	5	10	Remove shells; Test at 30°C
Peas, field--Pisum sativum var. arvense	B,T,S	20	3	8 [1/]	
Rape:					
Annual--Brassica napus var. annua	B,T	20-30	3	7	
Bird--Brassica campestris	P	20-30	5	10	Light. KNO_3
Turnip--Brassica campestris vars.	B,T	20-30	3	7	
Winter--Brassica napus var. biennis	B,T	20-30	3	7	
Redtop--Agrostis alba	P,TS	20-30	5	10	Light. KNO_3
Rescue grass--Bromus catharticus	P,S	10-30	7	28	Light; In soil at 15°C.
Rhodes grass--Chloris gayana	P	20-30	6	14	Light; KNO_3
Rice--Oryza sativa	B,T,S	20-30	5	14	

Table 2 (Cont'd)

Kind of Seed	Substrata	Temperature °C	First Count Days	Final Count Days	Additional Directions
Ricegrass, Indian--Oryzopsis hymenoides	P	15	7	42	Prechill at 5°C for 4 weeks and test for 21 addtional days.
Rough pea-Lathyrus hirsutus	T,B	20	7	14[1/]	
Rye-Secale cereale	P,T,S	20;15	4	7	Prechill at 5° or 10°C for 5 days.
Ryegrass:					
Italian--Lolium multiforum	P,TB	20-30;10-30	5	14	Light; KNO_3 and prechill at 5°C for 5 days.
Perennial--Lolium perenne	P,TB	20-30;10-30	5	14	Do.
Safflower-Carthamus tinctorius	P,T,B,S	15;20	4	14	Light at 15°C.
Sainfoin--Onobrychis viciaefolia	B,T	20-30	4	14[1/]	
Sesame--Sesamum orientale	P	20-30	3	6	
Sesbania--Sesbania Exaltata	T,B	20-30	5	7[1/]	
Smilo--Oryzopsis miliacea	P	20-30	7	42	Light. Prechill at 5° C for 2 weeks.
Sorghum alumum--Sorghum almum	B,T,S	20-35;15-35	5	21	Prechill at 5°C for 5 days.
Sorghum:					
Grain and Sweet--Sorghum vulgare	B,T,S	20-30	4	10	Prechill at 5°C or 10°C for 5 days.
Sorghum almum--Sorghum almum	B,T,S	20-35;15-35	5	21	Prechill at 5°C for 5 days.
Sorgrass[3/]	B,T,S	20-35;15-35	5	21	
Soybean--Glycine max	B,T,S	20-30;25	5	8[1/]	
Sudan grass-Sorghum sudanense	B,T,S	20-30	4	10	Prechill at 10°C for 5 days.
Sunflower (Cult.)--Helianthus annuus	T,B	20-30	3	7	
Sweet vernal grass--Anthoxanthum odoratum	P	20-30	6	14	Light.
Switch grass--Panicum virgatum	P,TS	15-30	7	28	Light; KNO_3. Prechill at 5°C for 2 weeks.
Timothy-Phleum pratense	P,TB	20-30	5	10	Light; Prechill at 5° or 10°C for 5 days.
Trefoil:					
Big-Lotus uliginosus (L. major)	B,T	20	5	12[1/]	
Birdsfoot--Lotus corniculatus	B,T	20	5	12[1/]	

Table 2 (Cont'd)

Kind of Seed	Substrata	Temperature °C	First Count Days	Final Count Days	Additional Directions
Tobacco--Nicotiana tabacum	P,TB	20-30	7	14	Light.
Vasey grass--Paspalum urvillei	P	20-35	7	21	Light. KNO_3.
Veldtgrass--Ehrharta calycina	P	10-30	7	28	Light.
Velvetgrass-Holcus lanatus	P	20-30	6	14	Light.
Vetch:					
Common--Vicia sativa	T,B	20	5	10 1/	
Hairy--Vicia villosa	T,B	20	5	14 1/	
Hungarian--Vicia pannonica	T,B	20	5	10 1/	
Monantha--Vicia articulata (V. monantha)	T,B	20	5	10 1/	
Narrowleaf--Vicia angustifolia	T,B	20	5	14 1/	
Purple--Vicia atropurpurea	T,B	20	5	10 1/	
Woollypod--Vicia dasycarpa	T,B	20	5	14 1/	Prechill at 10°C for 5 days and test at 15°C.
Wheat:					
Common, club, Polish (including spelt & emmer)--Triticum spp.	B,T,S	20;15	4	7	Prechill at 5° or 10°C for 5 days.
Durum--Triticum durum	B,T,S	20;15	4	10	
Wheatgrass:					
Crested, Fairway--Agropyron cristatum	P,TB	20-30;15-25	5	14	Light optional, KNO_3 and prechill at 5° or 10°C for 7 days.
Crested, Standard--Agropyron desertorum	P,TB	20-30;15-25	5	14	Light optional.
Hairy intermediate--Agropyron tricophorum	P	20-30	5	28	Light.
Alternate method		15-25	5	28	Light optional.
Intermediate--Agropyron intermedium	P	20-30	5	28	Light.
Alternate method		15-25	5	28	Light optional.
Slender--Agropyron trachycaulum	P,TB	20-30	5	14	Light. Prechill at 5° or 10°C for 5 days. If still dorment on 10th day, rechill 2 days; then place at 20-30°C for 4 days. (additional)
Tall-Agropyron elongatun	P	20-30	5	21	Light, KNO_3 and prechill at 5°C for 5 days.
Alternate method	P	15-25	5	21	Light optional
Western--Agropyron smithii	B,P,T	15-30	7	28	KNO_3 or soil.
Wild-rye, Canada-Elymus canadensis	P	15-30	7	21	Light.
Wild-rye, Russian--Elymus junceus	P	20-30	5	14	Light, Prechill at 5° or 10°C for 5 days.

Table 2 (Cont'd)

Kind of Seed	Substrata	Temperature °C	First Count Days	Final Count Days	Additional Directions
VEGETABLE AND HERB SEED					
Anise--Pimpinella anisum	B,T	20-30	6	14	
Artichoke--Cynara scolymus	B,T	20-30	7	21	
Asparagus--Asparagus officinalis	B,T,S	20-30	7	21	
Balm--Melissa officinalis	P	20-30	6	21	Light.
Basil, sweet--Ocimum basilicum	B,T	20-30	4/	14	KNO_3
Beans;					
Asparagus--Vigna sesquipedalis	B,T,S	20-30	5	8 1/	
Garden--Phaseolus vulgaris	B,T,S	20-30;25	5	8 1/	
Horse or broad--Vicia faba	S,C	20	4	14	Prechill at 10°C for 3 days.
Lima--Phaseolus lunatus var. Macrocarpus	B,T,C,S	20-30	5	9 1/	
Runner--Phaseolus coocineus	B,T,S	20-30	5	9 1/	
Beet-Beta vulgaris	T,B,S	20-30	3	14	
Belladonna--Atropa belladonna	P	20-30	12	28	Light; KNO_3
Borage--Borago officinalis	P	20	4/	10	Light.
Broccoli-Brassica oleracea var. botrytis	T,B,P	20-30	3	10	Prechill at 5° or 10°C for 3 days; KNO_3 and light.
Brussels sprouts--Brassica var. gemmifera	T,B,P	20-30	3	10	Do.
Cabbage--Brassica oleracea var. capitata	T,B,P	20-30	3	10	
Caraway-Carum carvi	P	20-30	6	14	Light.
Cardoon-Cynara cardunculus	B,T	20-30	7	21	
Carrot-Daucus carota	T,B	20-30	6	21	
Catnip--Nepeta cataria	TB	20-30	7	21 1/	
Cauliflower-Brassica oleracea var. botrytis	T,B,P	20-30	3	10	
Celeriac--Apium graveolens var. rapaceum	P	15-25;20	10	21	Light

Table 2 (Cont'd)

Kind of Seed	Substrata	Temperature °C	First Count Days	Final Count Days	Additional Directions
Celery-Apium graveolens var. dulce	P	15-25;20	10	21	Light
Chervil--Anthriscus cerefolium	P	20-30	7	21	Light.
Chicory-Cichorium intybus	P,TS	20-30	5	14	Light; KNO_3 or soil
Chives--Allium schoenoprasum	B,T	20	6	14	
Citron--Citrullus vulgaris	T,B	20-30	7	14	Soak seeds 6 hours. Test at 30°C.
Collards--Brassica oleracea var. acephela	T,B,P	20-30	3	10	
Coriander-Coriandrum sativum	B,T	15	6	21	
Corn, sweet-Zea mays	B,T,S	20-30;25	4	7	
Cornsalad (Fetticus)--Valerianella locusta var. olitoria	T,B	15	7	28	Test at 10° or 15°C.
Cowpea--Vigna sinensis	B,T,S	20-30	5	8[1]/	
Cress:					
Garden--Leipdium sativum	T,B,P	15	4	10	Light.
Upland--Barbarea verna	P	20-30	4/	7	Light; KNO_3.
Water--Rorippa nasturtium-aquaticum	P	20-30	4	14	Light.
Cucumber--Cucumis sativus	B,T,S	20-30	3	7	Keep substratum on dry side
Cumin--Cuminum cyminum	TB	20-30	6	14	
Dandelion--Taraxacum officinale	P,TB	20-30	7	21	Light
Dill-Anethum graveolens	B,T	20-30	7	21	
Eggplant--Solanum melongena var. esculentum	P,TB,RB	20-30	7	14	Light; KNO_3.
Endive--Cichorium endivia	P,TS	20-30	5	14	Light; KNO_3 or soil.

See footnotes at end of table.

Table 2 (Cont'd)

Kind of Seed	Substrata	Temperature °C	First Count Days	Final Count Days	Additional Directions
Fennel--Foeniculum vulgare	B,T	20-30	6	14	
Kale--Brassica oleracea var. acephela	T,B,P	20-30	3	10	Prechill at 5° or 10°C for 3 days; KNO_3 and light.
Kale, Chinese--Brassica oleracea var. alboglabra	P,B,T	20-30	3	10	Do
Kohlrabi--Brassica oleracea var. gongylodes	T,B,P	20-30	3	10	Do
Leek--Allium porrum	T,B	20	6	14	
Lettuce-Lactuca sativa	P	20	none	7	Light for at least 1/2 hour. Prechill at 10°C for 3 days or test at 15°C.
Marjoram, sweet--Origanum marjorane	B,T	15	4/	21	
Muskmelon--Cucumis melo	B,T,S	20-30	4	10	Keep substratum on dry side.
Mustard:					
India--Brassica juncea	P	20-30	3	7	Light. Prechill at 10°C for 7 days and test for 5 additional days; KNO_3.
Spinach--Brassica perviridis	B,T	20-30	3	7	
Okra--Hibiscus esculentus	T,B	20-30	4	14 1/	
Onion--Allium cepa	B,T	20	6	10	
Alternate method	S	20	6	12	
Pak-choi--Brassica chinensis	B,T	20-30	3	7	
Parsley--Petroselinum hortense(P. crispum)	T,B,TS	20-30	11	28	
Parsnip--Pastinaca sativa	T,B,TS	20-30	6	28	
Peas, garden--Pisum sativum	B,T,S	20	5	8 1/	
Pepper-Capsicum spp.	T,TB,RB	20-30	6	14	Light and KNO_3.
Pe-tsai (Chinese cabbage)--Brassica pekinensis	T,B	20-30	3	7	

Table 2 (Cont'd)

Kind of Seed	Substrata	Temperature	First Count	Final Count	Additional Directions
		°C	Days	Days	
Pumpkin-Cucurbita pepo	B,T,S	20-30	4	7	Keep substratum on dry side
Radish-Raphanus sativus	B,T	20	4	6	
Rhubarb--Rheum rhaponticum	TB, TS	20-30	7	21	
Roquette-Eruca sativa	B,T	20	4/	7	
Rosemary--Rosmarinus officinalis	P	15	7	28	Light
Rutabaga--Brassica napus var. napobrassica	B,T	20-30	3	14	
Saffren, false--Carthamus tinctorius	P,T,B,S	15;20	4	14	Light at 15°C
Sage--Salvia officinalis	B,T,S	20-30	5	14	
Salsify--Tragopogon porrifolius	T,B	15	5	10	Prechill at 10°C for 3 days.
Savory--Satureja hortensis	B,T	20-30	5	21	
Sorrel--Rumex acetosa	P,TB, TS	20-30	3	14	Light. Test at 15°C.
Soybean (vegetable)--Glycine max	B,T,S	20-30;25	5	8 1/	
Spinach:					
Common--Spinacia oleracea	TB	15;10	7	21	Keep substratum on dry side
New Zealand--Tetragonia expansa	TS	10-30	5	28	Keep substratum on dry side
Alternate method	B,T	15	5	21	Remove pulp from "seeds"
Squash-Cucurbita moschata	B,T,S	20-30	4	7	Keep substratum on dry side
Swiss chard--Beta vulgaris var. cicia	T,B,S	20-30	3	14	
Thyme-Thymus vulgaris	B,T	15	4/	21	
Tomato:					
Common-Lycopersicon esculentum	T,B,P,RB	20-30	5	14	Light; KNO_3.
Husk-Physalis pubescens	P,TB	20-30	7	28	Light; KNO_3
Turnip-Brassica rapa	T,B	20-30	3	7	
Watermelon-Citrullus vulgaris	B,T,S	20-30;25	4	14	Keep substratum on dry side. Test at 30°C.

1/ Hard seeds often present;
2/ Firm ungerminated seeds frequently present.
3/ Rhizomatous derivatives of a Johnsongrass x sorghum cross or a Johnsongrass x sudangrass cross.
4/ Make first count when necessary or desirable.

Table 3.

Tolerances for Pure Seed Variations for Nonchaffy Seeds

Computed on the Basis of Tolerances (T) = 0.6 plus 20% of the formula "P" X "q" divided by 100.

Value %	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Value %
100	0.60										100
99	0.79	0.77	0.75	0.73	0.71	0.69	0.67	0.65	0.63	0.61	99
98	1.00	0.98	0.96	0.94	0.92	0.90	0.88	0.87	0.85	0.83	98
97	1.18	1.16	1.14	1.12	1.10	1.08	1.06	1.05	1.04	1.01	97
96	1.36	1.34	1.33	1.31	1.29	1.27	1.25	1.23	1.21	1.20	96
95	1.55	1.52	1.50	1.48	1.46	1.45	1.44	1.42	1.40	1.38	95
94	1.72	1.71	1.69	1.67	1.65	1.63	1.62	1.60	1.58	1.56	94
93	1.90	1.88	1.86	1.85	1.83	1.81	1.79	1.78	1.76	1.74	93
92	2.07	2.05	2.03	2.02	2.00	1.98	1.96	1.95	1.93	1.91	92
91	2.23	2.22	2.20	2.18	2.17	2.15	2.13	2.12	2.10	2.08	91
90	2.40	2.38	2.36	2.35	2.33	2.31	2.30	2.28	2.27	2.25	90
89	2.55	2.54	2.52	2.51	2.49	2.47	2.46	2.44	2.43	2.41	89
88	2.71	2.68	2.67	2.66	2.65	2.63	2.62	2.60	2.58	2.57	88
87	2.86	2.84	2.83	2.81	2.80	2.78	2.77	2.75	2.74	2.72	87
86	3.00	2.99	2.97	2.96	2.95	2.93	2.92	2.90	2.89	2.87	86
85	3.15	3.13	3.12	3.10	3.09	3.07	3.06	3.05	3.03	3.02	85
84	3.28	3.27	3.26	3.24	3.23	3.21	3.20	3.19	3.17	3.16	84
83	3.42	3.40	3.39	3.38	3.36	3.35	3.34	3.32	3.31	3.30	83
82	3.55	3.53	3.52	3.51	3.50	3.48	3.47	3.46	3.44	3.43	82
81	3.67	3.66	3.65	3.64	3.62	3.61	3.60	3.59	3.57	3.56	81
80	3.80	3.78	3.77	3.76	3.75	3.73	3.72	3.71	3.70	3.68	80
79	3.91	3.90	3.89	3.88	3.87	3.85	3.84	3.83	3.82	3.81	79
78	4.03	4.02	4.00	3.99	3.98	3.97	3.96	3.95	3.94	3.92	78
77	4.14	4.13	4.12	4.10	4.09	4.08	4.07	4.06	4.05	4.04	77
76	4.24	4.23	4.22	4.21	4.20	4.19	4.18	4.17	4.16	4.15	76
75	4.35	4.33	4.32	4.31	4.30	4.29	4.28	4.27	4.26	4.25	75
74	4.44	4.43	4.42	4.41	4.40	4.39	4.38	4.37	4.36	4.35	74
73	4.54	4.53	4.52	4.51	4.50	4.49	4.48	4.47	4.46	4.45	73
72	4.63	4.62	4.61	4.60	4.59	4.58	4.57	4.56	4.56	4.55	72
71	4.71	4.70	4.70	4.69	4.68	4.67	4.66	4.65	4.64	4.64	71

Table 3 (Cont'd)

Value %	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Value %
70	4.80	4.79	4.78	4.77	4.76	4.75	4.75	4.74	4.73	4.72	70
69	4.87	4.87	4.86	4.85	4.84	4.83	4.83	4.82	4.81	4.80	69
68	4.95	4.94	4.93	4.93	4.92	4.91	4.90	4.90	4.89	4.88	68
67	5.02	5.01	5.00	5.00	4.99	4.98	4.98	4.97	4.96	4.95	67
66	5.08	5.08	5.07	5.06	5.06	5.05	5.04	5.04	5.03	5.02	66
65	5.15	5.14	5.13	5.13	5.12	5.11	5.11	5.10	5.10	5.09	65
64	5.20	5.20	5.19	5.19	5.18	5.17	5.17	5.16	5.16	5.15	64
63	5.26	5.25	5.25	5.24	5.24	5.23	5.23	5.22	5.21	5.21	63
62	5.31	5.30	5.30	5.29	5.29	5.28	5.28	5.27	5.27	5.26	62
61	5.35	5.35	5.34	5.34	5.34	5.33	5.33	5.32	5.32	5.31	61
60	5.40	5.39	5.39	5.38	5.38	5.37	5.37	5.37	5.36	5.36	60
59	5.43	5.43	5.43	5.42	5.42	5.41	5.41	5.41	5.40	5.40	59
58	5.47	5.46	5.46	5.46	5.45	5.45	5.45	5.44	5.44	5.44	58
57	5.50	5.49	5.49	5.49	5.49	5.48	5.48	5.48	5.47	5.47	57
56	5.52	5.52	5.52	5.51	5.51	5.51	5.51	5.51	5.50	5.50	56
55	5.55	5.54	5.54	5.54	5.54	5.53	5.53	5.53	5.53	5.53	55
54	5.56	5.56	5.56	5.56	5.56	5.55	5.55	5.55	5.55	5.55	54
53	5.58	5.58	5.57	5.57	5.57	5.57	5.57	5.57	5.57	5.56	53
52	5.59	5.59	5.59	5.58	5.58	5.58	5.58	5.58	5.58	5.58	52
51	5.59	5.59	5.59	5.59	5.59	5.59	5.59	5.59	5.59	5.59	51
50	5.60	5.59	5.59	5.59	5.59	5.59	5.59	5.59	5.59	5.59	50

Table 4.

Tolerances for Pure Seed Variations for the Following Chaffy Grasses:

Agropyron, Agrostis, Alopecurus, Anthoxanthum, Arrhenatherum, Axonopus, Bromus, Chloris, Cynodon, Cynosurus, Dactylis, Deschampsia, Festuca, Holcus, Melinis, Panicum, Paspalum, Poa, Trisetum, and Zoysia and mixtures containing these kinds singly or combined in excess of 50%.

The tolerance is obtained by adding to the regular tolerance the product obtained by multiplying the regular tolerance by the lesser of "p" and "q" divided by 100.

Value %	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Value %
100	0.60										100
99	0.79	0.77	0.75	0.73	0.71	0.69	0.67	0.65	0.63	0.61	99
98	1.00	0.98	0.96	0.94	0.92	0.90	0.88	0.86	0.83	0.81	98
97	1.21	1.19	1.17	1.15	1.12	1.10	1.08	1.07	1.06	1.03	97
96	1.41	1.39	1.38	1.35	1.33	1.31	1.29	1.27	1.24	1.23	96
95	1.62	1.59	1.57	1.54	1.52	1.51	1.50	1.48	1.45	1.43	95
94	1.82	1.81	1.78	1.76	1.74	1.71	1.70	1.68	1.66	1.63	94
93	2.03	2.00	1.98	1.97	1.95	1.92	1.90	1.87	1.86	1.84	93
92	2.23	2.21	2.18	2.17	2.15	2.12	2.10	2.09	2.06	2.04	92
91	2.43	2.41	2.39	2.36	2.35	2.33	2.30	2.28	2.27	2.24	91
90	2.64	2.61	2.59	2.57	2.55	2.52	2.51	2.49	2.47	2.45	90
89	2.83	2.81	2.79	2.77	2.75	2.72	2.71	2.69	2.67	2.65	89
88	3.03	3.01	2.99	2.97	2.95	2.93	2.91	2.89	2.86	2.85	88
87	3.23	3.20	3.19	3.16	3.15	3.12	3.11	3.08	3.07	3.04	87
86	3.42	3.40	3.37	3.36	3.35	3.32	3.31	3.28	3.27	3.24	86
85	3,62	3.59	3.58	3.55	3.54	3.51	3.50	3.48	3.46	3.44	85
84	3.80	3.78	3.77	3.74	3.73	3.70	3.69	3.67	3.65	3.63	84
83	4.00	3.97	3.95	3.94	3.91	3.90	3.88	3.86	3.84	3.83	83
82	4.18	4.16	4.14	4.13	4.11	4.08	4.07	4.05	4.03	4.01	82
81	4.36	4.35	4.33	4.32	4.29	4.27	4.26	4.24	4.21	4.20	81
80	4.56	4.53	4.51	4.49	4.48	4.46	4.44	4.42	4.41	4.38	80
79	4.73	4.71	4.69	4.68	4.66	4.63	4.62	4.60	4.59	4.57	79
78	4.92	4.90	4.87	4.85	4.83	4.82	4.80	4.79	4.77	4.74	78
77	5.09	5.07	5.05	5.03	5.01	4.99	4.98	4.96	4.94	4.93	77
76	5.25	5.24	5.22	5.20	5.19	5.17	5.15	5.14	5.12	5.10	76
75	5.43	5.40	5.39	5.37	5.35	5.34	5.32	5.30	5.29	5.27	75
74	5.59	5.57	5.56	5.54	5.52	5.50	5.49	5.47	5.45	5.44	74
73	5.76	5.74	5.73	5.71	5.69	5.67	5.66	5.64	5.63	5.61	73
72	5.92	5.90	5.89	5.87	5.85	5.83	5.82	5.80	5.80	5.78	72
71	6.07	6.05	6.05	6.03	6.01	6.00	5.98	5.96	5.94	5.94	71

Table 4 (Cont'd)

Value %	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Value %
70	6.24	6.22	6.20	6.18	6.16	6.15	6.14	6.12	6.11	6.09	70
69	6.37	6.37	6.35	6.33	6.32	6.30	6.29	6.28	6.26	6.24	69
68	6.53	6.51	6.49	6.49	6.47	6.45	6.43	6.43	6.41	6.39	68
67	6.67	6.65	6.64	6.63	6.61	6.59	6.59	6.57	6.55	6.53	67
66	6.80	6.80	6.78	6.76	6.76	6.74	6.72	6.71	6.71	6.68	66
65	6.95	6.93	6.91	6.91	6.89	6.87	6.86	6.84	6.84	6.82	65
64	7.07	7.06	7.04	7.04	7.02	7.00	7.00	6.98	6.97	6.95	64
63	7.20	7.18	7.18	7.16	7.15	7.13	7.13	7.11	7.09	7.09	63
62	7.32	7.30	7.30	7.28	7.27	7.26	7.25	7.23	7.23	7.21	62
61	7.43	7.43	7.41	7.40	7.40	7.38	7.36	7.35	7.35	7.33	61
60	7.56	7.54	7.53	7.51	7.51	7.49	7.48	7.48	7.46	7.45	60
59	7.65	7.65	7.64	7.62	7.62	7.60	7.59	7.59	7.57	7.56	59
58	7.76	7.74	7.74	7.73	7.71	7.71	7.70	7.68	7.68	7.67	58
57	7.86	7.84	7.83	7.83	7.82	7.80	7.80	7.79	7.77	7.77	57
56	7.94	7.94	7.93	7.93	7.91	7.90	7.90	7.89	7.87	7.87	56
55	8.04	8.02	8.02	8.01	8.01	7.99	7.98	7.97	7.97	7.96	55
54	8.11	8.11	8.10	8.10	8.09	8.07	8.06	8.06	8.05	8.05	54
53	8.20	8.19	8.17	8.17	8.16	8.16	8.15	8.14	8.14	8.12	53
52	8.27	8.26	8.26	8.24	8.23	8.23	8.22	8.21	8.21	8.20	52
51	8.32	8.32	8.31	8.31	8.30	8.30	8.29	8.28	8.28	8.27	51
50	8.40	8.37	8.37	8.36	8.36	8.35	8.35	8.34	8.34	8.33	50

Table 5.

Tolerances for Weed Seed, Other Crop Seed, and Inert Matter for Nonchaffy Seeds.

Computed on the basis of Tolerance (T) = 0.2 plus 20% of the formula "r" x "s" divided by 100.

Value %	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Value %
0	0.20	0.21	0.23	0.25	0.27	0.29	0.31	0.33	0.35	0.37	0
1	0.39	0.41	0.43	0.45	0.47	0.49	0.51	0.53	0.55	0.57	1
2	0.59	0.61	0.63	0.65	0.66	0.68	0.70	0.72	0.74	0.76	2
3	0.78	0.80	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.94	3
4	0.96	0.98	1.00	1.02	1.04	1.05	1.06	1.08	1.10	1.12	4
5	1.15	1.16	1.18	1.20	1.22	1.23	1.25	1.27	1.29	1.31	5
6	1.32	1.34	1.36	1.38	1.39	1.41	1.43	1.45	1.46	1.48	6
7	1.50	1.51	1.53	1.55	1.56	1.58	1.60	1.62	1.63	1.65	7
8	1.67	1.68	1.70	1.72	1.73	1.75	1.77	1.78	1.80	1.82	8
9	1.83	1.85	1.87	1.88	1.90	1.91	1.93	1.95	1.96	1.98	9
10	2.00	2.01	2.03	2.04	2.06	2.07	2.09	2.11	2.12	2.14	10
11	2.15	2.17	2.18	2.20	2.22	2.23	2.25	2.26	2.28	2.29	11
12	2.31	2.32	2.34	2.35	2.37	2.38	2.40	2.41	2.43	2.44	12
13	2.46	2.47	2.49	2.50	2.52	2.53	2.55	2.56	2.57	2.59	13
14	2.60	2.62	2.63	2.65	2.66	2.67	2.69	2.70	2.72	2.73	14
15	2.75	2.76	2.77	2.79	2.80	2.81	2.83	2.84	2.86	2.87	15
16	2.88	2.90	2.91	2.92	2.94	2.95	2.96	2.98	2.99	3.00	16
17	3.02	3.03	3.04	3.06	3.07	3.08	3.10	3.11	3.12	3.13	17
18	3.15	3.16	3.17	3.19	3.20	3.21	3.22	3.24	3.25	3.26	18
19	3.27	3.28	3.30	3.31	3.32	3.33	3.35	3.36	3.37	3.38	19
20	3.40	3.41	3.42	3.43	3.44	3.45	3.47	3.48	3.49	3.50	20
21	3.51	3.52	3.54	3.55	3.56	3.57	3.58	3.59	3.60	3.62	21
22	3.63	3.64	3.65	3.66	3.67	3.68	3.69	3.70	3.72	3.73	22
23	3.74	3.75	3.76	3.77	3.78	3.79	3.80	3.81	3.82	3.83	23
24	3.84	3.85	3.86	3.87	3.88	3.89	3.90	3.91	3.92	3.93	24
25	3.95	3.95	3.96	3.97	3.98	3.99	4.00	4.01	4.02	4.03	25
26	4.04	4.05	4.06	4.07	4.08	4.09	4.10	4.11	4.12	4.13	26
27	4.14	4.15	4.16	4.16	4.17	4.18	4.19	4.20	4.21	4.22	27
28	4.23	4.24	4.24	4.25	4.26	4.27	4.28	4.29	4.30	4.30	28
29	4.31	4.32	4.33	4.34	4.35	4.35	4.36	4.37	4.38	4.39	29
30	4.40	4.40	4.41	4.42	4.43	4.43	4.44	4.45	4.46	4.47	30
31	4.47	4.48	4.49	4.50	4.50	4.51	4.52	4.53	4.53	4.54	31
32	4.55	4.55	4.56	4.57	4.58	4.58	4.59	4.60	4.60	4.61	32
33	4.62	4.62	4.63	4.64	4.64	4.65	4.66	4.66	4.67	4.68	33
34	4.68	4.69	4.70	4.70	4.71	4.71	4.72	4.73	4.73	4.74	34
35	4.75	4.75	4.76	4.76	4.77	4.77	4.78	4.79	4.79	4.80	35
36	4.80	4.81	4.81	4.82	4.83	4.83	4.84	4.84	4.85	4.85	36
37	4.86	4.86	4.87	4.87	4.88	4.88	4.89	4.89	4.90	4.90	37
38	4.91	4.91	4.92	4.92	4.93	4.93	4.94	4.94	4.94	4.95	38
39	4.95	4.96	4.96	4.97	4.97	4.97	4.98	4.98	4.99	4.99	39
40	5.00	5.00	5.00	5.00	5.01	5.01	5.02	5.02	5.03	5.03	40

Table 6.

Tolerances for Inert Matter, Weed Seed, and Crop Seed for Chaffy Grasses, as follows:

Agropyron, Agrostis, Alopecurus, Anthoxanthum, Arrhenatherum, Axonopus, Bromus, Chloris, Cynodon, Cynosurus, Dactylis, Deschampsia, Festuca, Holcus, Melinis, Panicum, Paspalum, Poa, Trisetum, and Zoysia and mixtures containing these kinds singly or combined in excess of 50%.

The tolerance is obtained by adding to the regular tolerance the product obtained by multiplying the regular tolerance by the lesser of "r" and "s" divided by 100.

Value %	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Value %
0	0.20	0.21	0.23	0.25	0.27	0.29	0.31	0.33	0.35	0.37	0
1	0.39	0.41	0.43	0.45	0.47	0.49	0.51	0.53	0.55	0.58	1
2	0.60	0.62	0.64	0.66	0.67	0.69	0.71	0.73	0.76	0.78	2
3	0.80	0.82	0.83	0.85	0.87	0.90	0.92	0.94	0.96	0.97	3
4	0.99	1.02	1.04	1.06	1.08	1.09	1.10	1.13	1.15	1.17	4
5	1.20	1.21	1.24	1.26	1.28	1.29	1.31	1.33	1.35	1.37	5
6	1.39	1.42	1.44	1.46	1.47	1.50	1.52	1.54	1.55	1.58	6
7	1.60	1.61	1.64	1.66	1.67	1.69	1.72	1.74	1.75	1.78	7
8	1,80	1.81	1.83	1,86	1.87	1.89	1.92	1.93	1.95	1.98	8
9	1.99	2.01	2.04	2.06	2.07	2.09	2.11	2.13	2.15	2.17	9
10	2.20	2.21	2.23	2.25	2.27	2.28	2.31	2.33	2.34	2.37	10
11	2.38	2.41	2.42	2.44	2.47	2.48	2.51	2.52	2.54	2.56	11
12	2.58	2.60	2.62	2.63	2.66	2.67	2.70	2.71	2.74	2.75	12
13	2.77	2.79	2.81	2.83	2.85	2.87	2.89	2.91	2.92	2.95	13
14	2.96	2.98	3.00	3.03	3.04	3.05	3.07	3.09	3.12	3.13	14
15	3.16	3.17	3.19	3.21	3.23	3.24	3.26	3.28	3.29	3.32	15
16	3.34	3.36	3.38	3.39	3.42	3.43	3.45	3.47	3.49	3.50	16
17	3.53	3.54	3.56	3.58	3.60	3.61	3.64	3.66	3.67	3.69	17
18	3.71	3.73	3.74	3.77	3.78	3.80	3.81	3.84	3.86	3.87	18
19	3.89	3.90	3.93	3.94	3.96	3.97	4.00	4.02	4.03	4.05	19
20	4.08	4.09	4.11	4.12	4.14	4.15	4.18	4.20	4.21	4.23	20
21	4.24	4.26	4.29	4.30	4.32	4.33	4.35	4.36	4.38	4.41	21
22	4.42	4.44	4.46	4.47	4.49	4.50	4.52	4.53	4.56	4.58	22
23	4.60	4.61	4.63	4.64	4.66	4.68	4.69	4.71	4.72	4.74	23
24	4.76	4.77	4.79	4.81	4.82	4.84	4.85	4.87	4.89	4.90	24
25	4.93	4.94	4.95	4.97	4.99	5.00	5.02	5.04	5.05	5.07	25
26	5.09	5.10	5.12	5.14	5.15	5.17	5.19	5.20	5.22	5.24	26
27	5.25	5.27	5.29	5.29	5.31	5.32	5.34	5.36	5.38	5.39	27
28	5.41	5.43	5.43	5.45	5.46	5.48	5.50	5.53	5.53	5.54	28
29	5.55	5.57	5.59	5.61	5.62	5.63	5.65	5.66	5.68	5.70	29
30	5.72	5.72	5.74	5.75	5.77	5.78	5.79	5.81	5.83	5.85	30
31	5.85	5.87	5.89	5.90	5.91	5.93	5.94	5.96	5.97	5.98	31
32	6.00	6.01	6.02	6.04	6.06	6.06	6.08	6.10	6.10	6.12	32
33	6.14	6.14	6.16	6.18	6.18	6.20	6.22	6.23	6.24	6.26	33
34	6.27	6.28	6.30	6.31	6.33	6.33	6.35	6.37	6.37	6.39	34
35	6.41	6.41	6.43	6.44	6.45	6.46	6.48	6.50	6.50	6.52	35
36	6.52	6.54	6.55	6.55	6.58	6.59	6.61	6.61	6.63	6.63	36
37	6.65	6.66	6.68	6.68	6.70	6.71	6.72	6.73	6.75	6.75	37
38	6.77	6.78	6.79	6.80	6.82	6.82	6.84	6.85	6.85	6.87	38
39	6.88	6.89	6.90	6.92	6.92	6.93	6.95	6.95	6.97	6.98	39
40	7.00	7.00	7.01	7.01	7.03	7.03	7.05	7.06	7.08	7.08	40

Table 7. Germination Tolerances

The following tolerances will be recognized between germination tests:

Range of Germination (Percent)	Allowable Tolerance (Percent)
97 to 100	4
95 to 96	5
90 to 94	6
80 to 89	7
70 to 79	8
60 to 69	9
Below 60	10

In all cases at least 400 seeds are to be tested for germination.

Minimum Equipment for Seed Testing Laboratory

The basic items of equipment needed to test seeds of crops most likely to be included in the certification programs and their purposes are as follows:

1. Moisture tester - of the electrical type, such as the Steinlite or Universal moisture testers. Used for determining moisture content in a few minutes time. The laboratory should be able to provide information on moisture content in connection with harvesting, drying, and storing of seeds, as well as determining if seeds meet certification standards.

2. Seed scale - to be used for weighing samples in the range of 200-300 grams for the Steinlite moisture tester and for the larger size working samples.

3. Weight-per-hectoliter apparatus - for use in connection with older model steinlite moisture testers and for determining seed weights if required by certification standards.

4. Boerner sampler - for preparing the working sample for analysis, for free-flowing seeds only, the larger size model should be obtained.

5. Torsion balance - for weighing seed separations of purity analysis.

6. South Dakota Seed Blower Model B - used as an aid to purity analysis to remove most of the light inert matter from samples before doing the purity analysis.

7. Germinator - an alternating temperature, daylight type so that any germination condition can be supplied. To be used mainly for seeds not germinated by the sand method, such as vegetables and grasses.

In addition to the above pieces of equipment, many other items and expendable supplies are necessary. The following tabulation includes most of the items that will be needed in the laboratory:

Purity workboards - for performing the purity analysis. May be made locally. One needed for each purity analyst. Some may prefer to do purity analyses directly on the table raised to correct height.

Forceps (tweezers) - several types are satisfactory for germination testing. Fine pointed forceps should be obtained for purity examinations.

Magnifiers - of 7X or 10X magnification, either of triplex or tripod type. One should be provided each analyst to aid in making identifications and seed separations.

Stereoscopic microscope - for making difficult purity separations and weed seed identifications. Should provide magnifications of 9X to 45X.

Small seed dishes - made of metal or glass, for holding purity separations while making the purity analysis and obtaining weights.

Small envelopes - for filing purity separations.

Large envelopes - 8 oz. capacity or greater, for filing remnant seed and purity separations.

Plastic boxes - approximately 8" x 8" x 2", for making germination tests with sand.

Petri dishes - 9 cm size. For making germination tests on grasses and other crops requiring light.

Paper substrata - for germination tests made in petri dishes or blotters. Must be non-toxic to seedlings.

Thermometers - for checking temperatures of germinator.

Sample pans - various uses around the laboratory for holding seed samples.

Laboratory work cards - for recording results of purity analyses germination tests, moisture tests, weight-per-hectoliter, etc. Items entered on the card would correspond to information required in each country.

Report forms - for reporting results of tests to persons who submitted samples for testing.

Office supplies - calculator, general supplies needed to take care of the administrative details, correspondence, and filing in connection with the work of the seed testing laboratory.

Set of screens or sieves - to aid in purity analysis by removing most material differing greatly in size from the pure seed.

Sand - washed river sand for germination tests. If it is not economical to use new sand for each test, the used sand must be sterilized before reuse. This can be done by boiling or by procuring special sterilizing equipment.

Counting plates - for counting large seeds.

For large operations, it is better if the seed analysts specialize only in seed testing. However, if called upon to do the sampling also, the laboratory should obtain the necessary probes and triers.

As the laboratory expands into other areas, begins testing more kinds of crops, begins specializing in certain fields, or begins a research program, certain other items of equipment will have to be added when the need is demonstrated.

Seed Testing References

Regardless of the equipment and furnishings, the laboratory will only be as efficient as its analysts. Good manuals and references are essential in aiding analysts in making their interpretations consistent with those of other laboratories. References which should be in every seed testing laboratory are:

Testing Agricultural and vegetable Seeds. USDA Handbook No. 30. Superintendent of Documents, Washington, D. C.

Seed Analysis, by Duane Isely. Iowa State College Book Store, Ames, Iowa.

Rules for Testing Seeds. Association of Official Seed Analysts. Mr. Dwight D. Forsyth, Secretary, Association of Official Seed Analysts, Agronomy Building, Department of Agriculture, Madison 6, Wisconsin.

International Rules for Seed Testing. Secretariat, ISTA, Ryksproefstation voor Zaadcontrole, Binnenhaven 1, Wageningen, Holland.

Contributions to Handbook on Seed Testing. Complete list avaiable from Mr. Forsyth.

Proceedings of the Association of Official Seed Analysts. Mr. Forsyth.

Proceedings of the International Seed Testing Association. Secretariat, ISTA, Ryksproefstation voor Zaadcontrole, Binnenhaven 1, Wageningen, Holland.

USDA photos on seed identification and normal and abnormal seedlings. List of available separates may be obtained from Office of Information, USDA, Washington 25, D. C.

Appendix 2 - Literature relating to seed testing.

I. Books:

1. U. S. Department of Agriculture. Testing Agricultural and Vegetable Seeds. J. S. Dept. Agri. Handbook No. 30, 1952.

2. Crocker, William and Lela V. Barton. Physiology of seeds. Chronica Botanica Co. Waltham, Mass. 1961.

3. Stanway, V. M. Manual for beginners in seed analysis. 140 pp. University of Missouri. 1952.

4. Hwathorn, L. R. and L. H. Pollard. Vegetable and flower seed production. Blakiston Co., N. Y. 1954.

5. Shoemaker, J. S. Vegetable growing. John Wiley, N. Y. 1953.

6. McCullough Seed Company. Farm and grass seed manual. J. Charles McCullough Seed Co., Cincinnati 1, Ohio. USA. 1950.

7. Martin, J. H. and W. H. Leonard. Principles of field crop production. MacMillan Co., N. Y. 1949.

8. Hughes, H. D., M. E. Heath and D. S. Metcalfe. Forage crops. Iowa State College Press, Ames, Iowa. USA. 1951.

II. Periodicals:

1. Proceedings of the Association of Official Seed Analysts. Published annually. Secretary-treasurer, Seed Division, Nebraska Dept. of Agriculture, Lincoln, Nebraska, U. S. A.

2. News Letter of the Association of Official Seed Analysts. Published about every three months. Address same as above.

3. Contributions Handbook on Seed Testing of the Association of Official Seed Analysts. Miscellaneous, separated mimeographed articles on seed testing and seed identification.

4. Seed Technologist News. Published by the Society of Commercial Seed Technologists.

5. Proceedings of the International Seed Testing Association. Editorial Office, The Danish State Seed Testing Station, Thorvaldsensvej 57, Copenhagen V., Denmark.

6. Publication on the identification of seeds. Photostatic prints of illustrations on seeds and keys and descriptions. A list of available publications may be obtained from the Office of Information, U. S. Department of Agriculture, Washington 25, D. C.

7. Seed World. 327 So. LaSalle St., Chicago 4, Illinois. USA. Issued bimonthly. The Seed World also published annually the Seed Trade Buyers Guide which is particularly valuable to seed analysts in that it contains a summary of state and federal seed laws.

8. Southern Seedsman. 4900 Broadway, San Antonio 9, Texas. USA.

9. Seed Trade News. 309 N. Dearborn St., Chicago 2, Illinois, USA. Issued weekly.

III. Periodicals or bulletin series in agriculture.

1. Agronomy Journal; What's new in crops and soils. 2702 Monroe St., Madison 5, Wisconsin.

2. Contributions Boyce Thompson Institute. Yonkers, New York. Numerous publications on seed physiology. A list of available reprints may be obtained from the Institute.

3. Plant Physiology. Issued quarterly.

4. U. S. Department of Agriculture Bulletins and Yearbooks. U.S.D.A. bulletins are mostly in four series: Bulletins, Farmers' Bulletins, Circulars, and Miscellaneous Publications. A list of available publications is available from the Office of Information, U.S. Department of Agriculture, Washington 25, D.C.

5. State Agricultural Experiment Station Bulletins.

6. Biological Abstracts. University of Pennsylvania, 3613 Locust St., Philadelphia 4, PA. USA.

Appendix 3.

Glossary of Seed

1. Abscission layer	Layer of cells related to the separation of a plant part, such as a leaf or fruit, from the plant. Structure changes (dissolution) in the abscission layer precede separation. In rice, the ehickness of the abscission layer between the spikelet and the pedicel is reported to be associated with the ease of shedding in certain varieties.
2. Aleurone layer	The peripheral layer of the endosperm, containing oil and protein but no starch.
3. Caryopsis	The mature fruit of grasses in which the seed coat firmly adheres to the pericarp.
4. Chalaza	That part of an ovule or seed where the nucellus is not separated from the integuments; it is the base of the nucellus and is always opposite the upper end of the cotyledons; it is evident on the surface of seeds of many legumes as a distinct spot or elevation. The basal region of an ovule or seed, where the nucellus and integument(s) converbe; opposite from the micropyle.
5. Coleoptile	A sheath like lead of grasses and other monocotyledons that protects the delicate growing point as it emerges from the soil.
6. Coleorhiza	In the Poaceae, the sheath surrounding the embryonal root tip.
7. Cotyledon	A single terminal protuberance located precisely on the embryonic axis (monocotyledony), or two terminal protuberances located laterally with reference to the embryonic axis (dicotyledony).
8. Cotyledonary Node	The point of attachment of the cotyledons (in other than monocotyledonous plants) to the embryonal axis.
9. Embryo	The miniature plant developed from the fertilized (diploid) egg, the zygote, which upon germination gives rise to a young seedling. The basic parts of a mature embryo are the embryonic axis and the scutellum. The embryo is appressed to the endosperm by the scutellum. The embryo lies on the central side of the caryopsis next to the lemma. It is easily detached and removed in the milling process as part of the bran.

10. Embryonic axis — The plumule enclosed by the coleoptile and the radicle ensheathed by the coleorhiza form the embryonic axis in the embryo.

11. Embryo Sac — The ovular cavity, formerly occupied by the megagametophyte, in which an embryo develops (often erroneously applied to the megagametophyte).

12. Endosperm — A coenocytic or cellular, evanescent or permanent, tissue arising in the embryo sac; derived from the fertilized or unfertilized polar nucleus (haploid) or primary endosperm nucleus (which may be diploid, triploid or tetraploid) as a result of fusion with the secondary male nucleus.

13. Epiblast — A small structure opposite the scutellem in the embryo. Sometimes considered to be a rudimentary cotyledon. It has no vascular tissue.

14. Epicotyl — That portion of the embryonic axis (Usually not recognizable until after germination) above the cotyledonary node.

15. Epigeal — Plants in which the cotyledons appear above the surface of the soil.

16. Floret — A unit of the spikelet, including the lemma, palea, and the enclosed flower.

17. Fruit — The mature ovary and any associated parts.

18. Funiculus — The stalk by which a seed or ovule is attached to the ovary.

19. Hilum — The scar left on the seed at the place of detachment from its base or seed stalk.

20. Hull — (Syn. husk, chaff). Includes the lemma and palea. Structures such as the rachilla, sterile lemmas, the awn if present, and broken segment of the pedicel are usually associated with the hull, if they survive the threshing process.

21. Hypocotyl — That portion of the embryonal axis between the root and the cotyledonary node.

22. Hypogeal — Plants in which the cotyledons remain below the surface of the soil.

23. Integument	One (single) or two (inner and outer) protective coverings of the ovule, usually only a few cells in thickness.
24. Keel	A sharp longitudinal fold, like the ridge of a boat.
25. Mesocotyl	The internode between the scutelar node and the coleoptile in the embryo. In the young seedling, mesocotyl is the internode between the coleoptile node and the point of union of the culm and root. Its length can be measure only when the seedlings are grown in the dark or from the underground portion of the seedling.
26. Micropyle	The pore or opening through which the pollen tube enters the embryo sac during the fertilization process.
	The orifice between the integument or integuments at the apical end of an ovule.
27. Nucellus	All that portion of an ovule exclusive of the integument(s), archesporium, megasporocyte, megaspores or megagametophyte.
	Tissue in the centralppart of the ovule in which the embryo sac is embedded.
28. Ovule	The body within the ovary of the flower that becomes the seed after fertilization and development.
29. Panicle	The determinate inflorescence of rice with a racemose mode of branching, bearing pediceled spikelets and flowering from the apex downward.
30. Pedicel	The stalk supporting a spikelet on the panicle branch. The distal end appears as a lobed cup, representing two rudimentary glumes (facet).
31. Pericarp	The covering of a seed that is derived from the ovary wall. It may be thin and intimately attached to the seedcoat, as in a kernel of corn; fleshy, as in berries; or hard and dry, as in pods and capsules.
32. Plumule	Sometimes applied to the growing point or stem apex of the embryo; not in common use in embryology.
33. Rachilla (syn. rhachilla, callus).	A diminutive axis between the rudimentary glumes, the sterile lemmas, and the fertile floret. It rarely branches.

34. Radicle — A rudimentary root, the lower end of the hypocotyl of the embryo. It forms the primary root of the young seedling.

35. Raphe — A lone or ridge of the ovule which runs from the hilum to the chalaza in anatropous and amphitropous seeds.

36. Root cap — The external covering of the root tip; derived from the calyptroger of dermatocalyptrogen on older and germinating embryos, but originating from the lower cells of the proembryo in various ways.

37. Rudimentary (embryo) — An embryo which is imperfectly developed and functionally useless.

38. Scutellum — A shield-shaped organ of the developing embryo within a seed. The embryo absorbs food from the scuellum, much of which is in turn obtained from the endosperm. In certain plants, like corn, it is a specially developed cotyledon.

39. Seed — A mature ovule, consisting of an embryonic plant together with a store of food, all surrounded by a protective coat. It usually develops after the fertilization of an egg cell by a male generative cell from a pollen grain. Seeds of some species develop without the intervention of the male cell; formed entirely of mother tissue, such seeds are called apogamic seeds.

40. Spikelet — A unit of the rice inflorescence consisting of the two sterile lemmas, the rachilla and the floret. The two rudimentary glumes are considered to be a part of the spikelet.

41. Tegmen (Syn. seed coat) — The two layers of cells lying next to the pericarp, representing the inner cell layers of the inner integuments of the ovule. The tegmen is often mistermed as testa which is derived from the outer integuments of the ovule and which is destroyed before the caryopsis ripens.

REFERENCE

1. Association of Official Seed Analysts. Rule for Testing Seeds. Proc. Assoc. Off. Seed Anal. Vol. 49, No. 2. 1960

2. Duane Isely. Seed analysis. Iowa State College. 1961

3. International Seed Testing Association. International rules for seed testing. Proc. Int. Seed Test. Assoc. Vol. 24, No. 3. 1959

4. Mississippi Seed Technology Laboratory. Seed certification. Miss. State University. 1960

5. Mississippi Seed Technology Laboratory. Seed Testing. Miss. State University. 1958

6. Mississippi Seed Technology Laboratory. Articles closely related to seed improvement. Miss. State University. 1958

7. Porter, R.H. Manual for seed technologists. Publication No. 7. Amer. University of Beirut. 1959

8. United Stated Department of Agriculture. Manual for testing agricultural and vegetable seeds. Agricultural handbook No. 30. 1952

9. United States Department of Agriculture. "SEEDS" Yearbook of agriculture.

10. Proceeding of the International Seed Testing Association, Vol. 29, Nov. 1964