SEED QUALITY CONTROL IN THE FIELD

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Pre-harvest crop management for quality seed

The management of the crop will influence the time and uniformity of crop maturity. Basic requirements of good crop management include good water, nutrient, pest and harvest management.

Plant technique and population

Establishing the correct number of plants is essential to maximize water and nutrient use. A target population that results in 400-500 panicles per m^{-2} is desirable. This means establishing at least 70-100 seedling m^{-2} when transplanting, or broadcasting 80-120 kg seed ha^{-1} when direct seeding.

Low populations may result in:

- increased tillering, which creates more variation in panicle maturity
- increased weed populations
- reduced yield potential of the variety.

High plant populations may reduce yield and quality by:

- competing for water and nutrients
- mutual shading
- lodging and reduced grain size.

Water management

To be able to manage water, the fields must be level and the bunds or levees well maintained. Uniform water depth across the field will contribute to a more uniform crop, higher seed yields and consistent moisture content in the grain sample. Reducing the variation in moisture content at harvest reduces the chance of seed damage from disease.

Good water management helps reduce weed competition, which not only increases yields but also improves seed quality by reducing dockage levels and reducing moisture differentials between weed seeds and grain. Wet spots in the seed due to uneven drying or weed seeds can lead to disease and loss of quality.

Nutrient Management

The application of the correct level and type of fertilizer for the variety and growing conditions is essential. The prudent application of nitrogen is essential to get an evenly maturing crop with full grain size. Excessive and uneven application of N can stimulate late tiller production which results in heads on the main culm ripening a number of days faster than the tillers. This results in more immature and green heads in the sample as well as higher moisture content that increases the chance of spoilage by disease. Conversely insufficient nitrogen can lead to reduced grain size and poor vigor.

Roguing

Every field should be rogued to remove off-types, any plants of another crop or variety, and diseased plants. Characteristics that can be used to determine varietal purity under field conditions include plant height, pigmentation of plant parts, pubescence, awn characteristics and time of flowering. Roguing should be done at least once before flowering and once after flowering.

Field inspection

Seed quality includes genetically purity, physical purity, germination capacity, moisture content, health and vigor. The quality possessed by the lot or stock is to be ascertained field stands. All except genetic purity can be determined in the Seed Testing Laboratory by testing the seed following prescribed procedure for Seed Testing. Seed testing procedure has been prepared by following the guidelines given in the ISTA proceeding. Genetic purity is to be ascertained by growing crops in the field undertaking field Inspection. As such it is necessary to accomplish the following two activities in order to provide quality assurance. Seed are tested in a laboratory following set procedure. The results obtained in the tests provide indication of the physical and physiological qualities and health status of the seed under test thereby of the lot or stock.

Field Inspection is the act of performing the field operations like counting percentage of undesirable plants and diseases plants, ascertaining isolation distances of the seed crop etc, and finally declaring acceptability or non-acceptability of the seed crop. After doing field inspection advice is also given to the growers for necessary rectification for his seed crop field. Field Inspection and seed testing are the main two tools for executing any schemes like Seed Certification, Truthfully Labeling and Market Monitoring required for controlling quality of the seed for sale. Field Inspection procedure has been described by SCA following guidelines available in OECD certification scheme and experience gained in producing seed in the country. Seed standards fixed by the NSB are followed respectively during the field inspection of the seed crop and laboratory test of the seed samples.

In most countries when a crop is intended for certification it must be inspected prior to harvest. A representative of the certifying agency inspects the crop at least once during the vegetative stage and normally once at pre-harvest stage. The crop may be refused certification due to unsatisfactory appearance caused by weeds, poor growth, poor stand, disease, insect damage and any other condition which prevents accurate inspection or creates doubt as to the identity of the variety. Each country has field standards for the allowable number of off types, unacceptable weed types and numbers of diseased plants.

Inspection of the seed crops standing in the field is Field Inspection. It is an essential means to verify conformity of seed crops with the Field Standard (Table 1) prescribed by the National Seed Board. Examination of growing plants in the seed crop field and in the post control plots is the practical means of assuring cultivar purity of seed stock under multiplication.

Objective of Field Inspection

- to verify seed origin (source seed) and identify of the variety;
- to collect information on cropping history of the seed field, that is, to verify whether the seed field meets the prescribed land requirements; ,
- to check crop and cultivation conditions;
- to check isolation distance;
- to check freedom from impurities i.e. other crop plants and obnoxious weed, other variety, off-type and weeds;
- to check freedom from seed borne diseases.

Field selection and land preparation

In most countries, fields used for growing certified seed must meet a number of criteria. These include:

- Not have grown rice for the previous year unless the rice was the same variety planted for certification and met inspection requirements for varietal purity.
- Separation from other fields of same variety by a ditch, levee or roadway or barren strip of at least 3 meters distance must be maintained to preclude contamination through chance out crossing.

- Thorough land preparation should be done to eliminate volunteer plants and control weeds especially during the fallow or non-cropped period. Fields should be cultivated or chemically controlled with herbicides to ensure that weeds and volunteer rice plants do not seed.

Principles of field inspection

Origin and identity of parent seed: It is essential that a seed crop is produced from a known parent seed source. In order to authenticate the identity of seed sown, growers should retain at least one label from each seed lot used to sow the crop. The purpose of this procedure is to check details provided on the label against those on crop inspection form, and to confirm the identity of variety. For hybrids, labels of the seed lots used for male parent and for female parent must be kept and verified.

Cropping history of field: The crop inspector should interview the grower of seed crop concerning details of the previous cropping of the field. The grower should provide details relating to the crops grown on the field in previous years. Crop rotation in seed production is a common practice to avoid cultivar contamination and disease incidence.

Isolation: Proper isolation of the seed crop is necessary to prevent out crossing/pollination and mechanical admixtures. Isolation of the seed crop should be checked while walking around its perimeter. Inspection for crop species which are cross-pollinated by insects or wind, will involve checking all surrounding fields for any crops lying within the minimum prescribed isolation distances which might cross-pollinate with the seed crops.

Off-types: The first function of the field inspection is to examine the seed crop as a whole to ensure it is consistent with the characteristics of the variety given in the official description. This is usually done by walking into the seed crop and examining a reasonable number of plants. Off-types are plants of the same species which do not exhibit the acceptable characteristics of the seed crops being grown. If not rogued in time, such off-types will affect the genetic purity of the seed crops. Other crop plants are also undesirable and need to be removed as soon as noticed.

Weeds and other crop species: Apart from the already known effects of weeds in crop production, weeds can also make inspections difficult. Weeds affect the physical purity of the harvested crop. On the other hand, the presence of a number of crop species creates problems not only in the seed crops but also in the processing of the seed. There are also a number of weed species which can prove difficult to clean from seed during seed processing.

Diseases: As seed is one of the major ways of disease propagation, control of seed borne diseases can prevent crop disasters. Estimates of diseased plants should invariably be made through actual counts.

General crop condition: After having examined the field as a whole, the inspector should examine the field in more detail, especially around the perimeter. Observations should be made for signs which would indicate that part of the field might have been sown with different seed that might contaminate the seed crop. Particular attention should also be given to the presence of other crop species, weeds, seed-borne diseases, and verification of isolation from sources of contaminating pollen. Crops which are severely lodged, badly infested with weeds, stunted or poorly grown because of disease, pests or other causes and which cannot be assessed for varietal purity should be rejected.

Checks and counts of field inspection

The grower or his/her representative should be allowed whenever possible to accompany the seed inspector during the field inspection. This is particularly important in the case of a crop rejection or withdrawal of the crop from the certification scheme. During the inspection, the crop should be checked thoroughly. A general view of the crop is first done, followed by a detailed inspection of the crop. A suitable walking pattern to maximize field coverage should be undertaken to ensure thorough examination of the field where the crop is obviously with the production standards further detailed prescribed standards and systematic random counts must be done. Once the process of random counts has started and from the observation it is evident that the crop will not meet or will meet the standards, the process should not be discontinued, but completed to establish the facts. The number of counts depends on the size of the area. Counts should be evenly distributed throughout the field or affected portion of the field without any bias.

Crop stage

A seed inspector has authority to visit and inspect any registered crop or any seed dealer at any reasonable time with or without appointment. Field inspection are done at various growth stages such as vegetative, flowering and maturity. It is important to inspect a seed crop at the right time in order to facilitate effective observation of the critical and stable characteristics which will enhance effective purity of the crop in question.

Points to be considered during field inspection

a) The minimum number of inspections indicated in the Seed Certification Standards should be conducted at prescribed stages;
b) It is to be ensured that counts are taken in correct seed field;
c) If seed growers are new, the standards and the principles and procedures of field inspection should be explained to them;
d) The seed grower or his representative who so ever present during the field inspection should be shown all factors observed in the field and which will be recorded in the inspection report;
e) If the crop is so weedy, damaged, or lodged that makes inspection difficult to judge the trueness of variety and varietal purity the seed field to be rejected;
f) If direction of plant rows permits, the Inspector should proceed in the seed field in such a manner that the sun is either toward his side, or back. It will help in identification of off-type, other varieties and diseased plants more easily and correctly;
g) During inspection, the principles of randomness and freedom from biasness should always be observed;
h) In all inspections only the prescribed number of counts should be taken, counts less or more than the number should not be taken;
i) If the plant population in the seed field is so thin that the entire population is less than the number required for the prescribed number of counts, the entire population should be counted;
j) Even if by observation it is clear that the seed crop will not conform to the required standards, it is advisable to make the required number of field counts and determine rates of occurrence of counted factors;
k) Counting should not be localized to a portion or a few portions of a field, but should be randomly distributed all over the field so that the counts are representative of the entire field;
1) Counting can be started from any randomly chosen side of the seed field, from any randomly chosen row and plant, and can be carried out in any randomly chosen direction. Spotting a defect and trying to include it in counts, or locating a defect and trying to avoid it introduce bias and are not desirable. However, the inspector should always be alert to determine the best position for spotting contaminating factors;
m) Counting in the row and shifting from row to row should be so arranged that the same plant is not counted twice;
n) Factors counted during inspection need not normally be pulled out by the Inspector. However, if the Inspector feels that it would be easier to convince the grower by pulling out the factors and showing them to the growers, it may be done;
0) Seed crop should not be disturbed unnecessarily during field inspection;
p) Seed Inspector should be frank and open to the growers and producers;
q) All necessary instructions and advice about identification of off-type, other varieties and diseased plants and removal of contaminations to be given to the producers.

Materials required during field inspection

Equipment and supplies are to be made available to the Seed Inspector during field inspection.

For efficient inspection the Inspector should have the following supplies according to need:

- Map of the area in which the seed field can be located;
- Preliminary details of seed fields to be inspected;

- Seed Certification Manual for prescribed field standards;
- Field Count Forms and Field Inspection Report Form (CIRF);
- Field map;
- Measuring tape (30 meters long);
- Binoculars;
- Clip board or writing board;
- Envelopes, stamps etc;
- Plastic, polythene or thick paper bags to hold specimens of plants picked during inspection for reference of consultation;
- Pencil, pen and other stationery;
- Small pocket note book;
- Tally counter;
- Flash light;
- A knife or scissors;
- Magnifying lenses;
- If available, an identification card or letter of introduction;
- A box to hold supplies;
- Rain coat or umbrella;
- Water bottle;
- Gum boots;
- A 1-1.5 meter long stick for marking.
- References, given morphological description of varieties, a weed identification manual, description of common crop diseases, other useful agronomic reference manuals and publications on seed production, certification, processing, storage;
- Field Inspection Manual.

Contaminants

The various contaminants are to be observed during field inspection can be broadly classified into the following categories:-

Off-types: Plant of the same crop species as the seed crop, differing in the expressing of morphological characters such as plant type, branching habit, pigmentation, etc., are to be classified as off-types. To designate a plant as off-type, it is not necessary to identify it definitely as of another variety.

Inseparable other crop plants: Inseparable other crop plants are plants of cultivated crops found in the seed field and whose seeds are so similar to the crop seed and it is difficult to separate them economically by mechanical means. An inseparable other crop plant is counted if its stage of growth is such that it would bear seed when the seed crop matures, and possibly cause mechanical admixture during harvesting and threshing.

Objectionable weed plants: These are plants of weed species whose seed size and shape are similar to that of crop seeds and which are difficult to remove from the seed economically by mechanical means. In addition to these species, such weed species whose eradication is difficult if once introduced, or those who serve as alternate hosts for crop pests or diseases, are also classed as objectionable weed plants. For counting, an objectionable weed plant is counted if its stage of growth is such that it will bear seed when the seed crop matures and possibly cause mechanical admixture during harvesting and threshing.

Diseased plants: The plants affected by designated diseases should invariably be counted. The grower should be advised to rogue them out from seed fields.

Field count

Number of Field Count

For all crops a minimum of five counts are taken for an area up to two hectares, and an additional count is taken for each additional two hectares or a part thereof, as given in Table 2.

Table 2 Minimum number of field counts

Area of the field (ha)	Minimum number of counts to be taken
Up to 2	5
above 2 to 4	6
above 4 to 6	7
above 6 to 8	8
above 8 to 10	9

In any inspection, if the first set of counts shows that the seed crop does not conform to the prescribed standards for any factor, a second set of counts should be taken for that factors, if the percentage of that factor is not more than twice the permissible limit called 'double counts'. If the seed field is planted with two different parents, the determined number of counts must be taken separately in each parent.

Number of plants

The number of plants to be observed for completing a single count vary from crop to crop. Table 3 gives the number of plants/heads to be observed for completing a single count.

Table 3 Number of plants /heads per count

Crops	Number of plants/ heads per count
Thickly- Sown crops: Jute, mesta, soybean, pearl millet, barley, oats, paddy, wheat, etc.	1000 Plants
Medium- Spaced row crops: Beans, cowpea, gram, leafy vegetables, mung bean, mustard, peas, sesame, sunhemp etc.	500 Plants
Wide-spaced row crops: Brinjal, bulb crops, chillies, cole crops, cotton, cucurbits, ground nut, maize, potato, pigeonpea, root crops, tomato etc.	100 Plants

Taking the field counts

The method of taking field counts varies somewhat in different crops. Illustrated below are some of the methods employed in different crops.

A. Thickly-sown row crops

(a) For wheat, barley, oats, soybean, jute mesta, etc:

i. Enter the seed field from a randomly selected site and determine the number of heads/plants in a row in one step at five different locations and work out the average number of heads/plants per step.
ii. Calculate the number of steps required to complete a count (e.g. one thousand heads for wheat). For example, if average number of heads/plants in one step is fifty; divide one thousand by fifty to determine that 20 steps will be needed to complete a count.
iii. Select at random any row and start from any point in that row. Take the required number of steps in one row to inspect one thousand heads/plants, or take enough consecutive steps to inspect one hundred heads/plants in that row, then cross over two or three rows and take the necessary steps to cover another one hundred from a point approximately parallel to the last step counted in the previous row and repeat the process until one thousand heads/plants have been inspected. The various contaminants observed mayor may not be pulled during inspection. After completing the count the number of each contaminant should be recorded on the inspection report.

(b) For paddy

Procedure for taking a count in paddy is similar to that mentioned above, except that paddy fields may be inspected by walking into the field from bunds that cross the area. The counts can be taken at pre-determined distances into the field from corners and from the edges.

i. Decide how many steps you will take from corners and into field before taking the first count. Counts from the centre of field should be a minimum of twenty steps from the edge.
ii. Using a metre stick determine the number of panicle in one line one metre long at five different locations. Calculate the average number of panicles per metre of row.
iii. Divide the number of heads in one metre lengths into one thousand to determine number of metre lengths to be inspected.
iv. Inspect the panicles in the required number of metre length. This may be in a straight continuous area one metre wide, or a compact area around the location. Record the number of each contaminants on the inspection report. This completes one count.

B. Medium spaced row crops

For beans, cowpea, gram, leaf crops, mustard, peas, moong, sesame etc.

The procedure for taking a field count is almost similar to that described earlier for thickly sown row crops, e.g. soybean. The only difference is in the number of plants required for completing one count. In these crops only five hundred plants are to be inspected to complete one count.

C. Wide-spaced row crops

For brinjal, bulb crops, capsicum, chillis, cole crops, cotton, cucurbits, ground nut, potato, red gram, root crops, tomato etc.

i. Start at random from any point in any row and inspect one hundred consecutive plants in one row or in a square of ten plants in each direction. Count the individual plants. If counting is made in a square, a predetermined number of rows could be crossed over after inspecting ten plants in a particular row.

ii. Observe and record the number of contaminants on the inspection report. This completes one count.

D. Broadcast crops

i. Using a one square metre frame, determine the plant population in a one square metre area, at five different locations. Calculate the average number of plants per square metre.
ii. Divide the number of plants in one square metre into one thousand to determine the number of square metres to be inspected for completing one count.
iii. Inspect the plants in the required number of squares by placing a one square metre frame either continuously in a compact location, or by placing it at a location and crossing over predetermined steps before placing it at another location. Repeat the process until one thousand plants have been inspected. Record the number of each contaminant observed during inspection on the inspection report. This completes one count.

Varietal purity test

Seed certification schemes, controlled pedigree systems and rules and regulations for seed growing and distribution are all aimed at maintaining cultivar trueness and purity of seed. In spite of this, possibilities always exist for unwanted seeds of other cultivars or other types to contaminate the originally pure seed lots.

Causes of contamination include:
1. natural crossing with another cultivar especially in open pollinated crops,
2. mutation,
3. unclean harvesting equipment,
4. carelessness at the processing plant and
5. mistakes in bagging and tagging.

To discover and control such contamination pre- and post-control tests are conducted by means of cultivar identification and purity determination.

Cultivar purity or genuineness of a cultivar is tested by means of heritable characters (morphological, physiological, chemical..etc.) of seeds, seedlings, plants or stands.

An authentic standard sample must be available for comparison which is required to be treated and examined in the same way as the sample under test. In other words, standard as well as test samples compared at the same stage of development grown under identical environmental conditions.

Characters for varietal purity test

The possibility to prove genuineness of a cultivar by field plot test is based on the hereditary characteristics of the plant. The characteristics used to distinguish varieties may be either (1) qualitative or (2) quantitative.

Qualitative characteristics are those which show discrete discontinuous states with no arbitrary limit on the number of stages. Whereas quantitative characteristics are those which are measurable on a one dimensional scale and show continuous variation from one extreme to the other.

Qualitative characteristics are normally recorded visually, whereas quantitative characteristics can be measured, in many cases, however, a visual assessment or if applicable, other sensory observations (e.g. taste, smell) are sufficient.

A combination of laboratory and field plot methods may be used to determine the cultivar trueness and genetic purity of the sample.

Laboratory methods based on examination of morphological seed characters, colour reaction to certain chemical treatment, properties of seedlings, response of seedlings to controlled environment and growth stimulants and stable plant characters are used to detect cultivar trueness. Therefore, the methods for varietal purity are divided in the following groups:

A. Examination of seed in the laboratory.
B. Examination of seedlings grown in a growth chamber or green house.
C. Field plot tests or grow-out test.

DUS test

In DUS growing test, candidate varieties are cultivated on fields and compared with similar existing varieties (reference varieties) and morphological characteristics (colors, shapes, size, etc.) and physiological characteristics (tolerance to diseases, etc.) are evaluated.

- **Distinctness**: New varieties should be clearly distinguishable from any other existing varieties.

- **Uniformity**: Individual plants of new variety should be sufficiently uniform at the same propagation stages.
- **Stability**: Characteristics of new variety should be stable through repeated propagation.

Guidance for examination

- Best Practice (base on experience)
- Good decisions
- Good definition of the object of protection (strong protection)
- Efficiency in method of examination (learn from the best)

Harmonization:

- Mutual acceptance of DUS report (minimize cost of examination)
- Mutual recognition of variety descriptions (all parties speak the same "language")
- Simple and cheap system applicants

Distinctness

Method of Observation

Side by side visual comparison

-Direct comparison in the field

Assessment by notes

- Recording of notes in trial
- Distinctness relate from notes afterwards

Statistical analysis

- Measurements in the trial
- Distinctness related from statistics afterwards

Consistent

Two independent occasions:

- Different sowings/ plantings in two different seasons (annual, perennial, e.g.rice)
- Two different seasons after a single planting.

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Uniformity

The variety must be sufficiently uniform in its relevant characteristics, subject to the variation that may be expected from the particular features of its propagation. When propagated, the essential features characterising the variety must remain unchanged.

Assessment of uniformity

Rice

- Within a population standard of 0.1% with an acceptance probability of at least 95%
- In the case of 400 plants sample, the maximum number of off-types would be 2.
- In case of 50 panicles rows the maximum number of aberrant panicle-rows, plants or parts of plants should not exceed 2.

Stability

Relevant characteristics must remain unchanged after repeated propagation.

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- A candidate will be considered to be sufficiently stable when there is no evidence to indicate that it lacks uniformity
- For many types of variety, when a variety has been shown to be uniform, it can also be considered to
- be stable.

- Where appropriate, or in cases of doubt, stability may be tested, either by growing a further generation, or by testing a new seed stock to ensure that it exhibits the same characteristics as those shown by the previous material supplied

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VCU Testing

Before a new variety can be registered and may be placed on the market, it needs not only to pass DUS testing, but also additional merit tests, the so called value for cultivation and use testing (VCU testing). VCU testing usually takes two to three years. A new variety has a value for cultivation and use if the examination shows that it presents an advantage over already registered varieties in its main cultivation and processing characteristics.

By VCU Tests also the following is defined:

- plant productivity;
- disease, pest and caranatine bodies persistance;
- phenological observations;
- biochemical and technological peculiarities.

DUS tests procedures

Requirements: Authentic seeds of existing varieties, pure seeds of variety under test, list of characters to be examined and their expression.

Method: Conduct test in the optimum conditions of soil and climate and the crop is exposed to the best agronomic management conditions to ensure full expression of the characters.

Establishment of distinctness: The variety under test is compared with the existing varieties (having similar plant height, growth habit, days to flowering, days to maturity and reaction to diseases) for qualitative morphological characters at seed, seedling and plant levels. Biochemical differences may also be considered. To establish the distinctness the test is performed for 2 years for self pollinated crops and 3 years for cross pollinated crops.

Establishment of uniformity

- Self-pollinated crops-1% off types is tolerated.
- Cereal-Variant ear rows are tolerated upto maximum of 3 in 150 rows.
- Cross pollinated crops-The uniformity of the variety under test is checked against known comparable varieties.

Establishment of stability: Stability for the expression of qualitative and quantitative traits is estimated over the year. In cereals more than 8 variants in 150 ear to row progeny of the variety is considered as unstable.

Distinguishing characters: Rice-Blade colour, basal leaf sheath, ligule, auricle, internode, awn apiculus, lemma and palea, seed coat, pubescence colour and its presence on blade, lemma and palea, angle of leaf, flag leaf and culm, presence ,shape and type of ligule, panicle and awn.

VCU tests procedures

Requirements: Authentic seeds of existing varieties, pure seeds of variety under test, list of characters to be examined and their expression

Method: Yielding ability, days to flowering, maturity and quality attributes of the newly evolved variety is compared with the existing cultivars in different agro-climatic conditions for 2-3 years.

Zadoks scale

The Zadoks scale is a cereal development scale proposed by the Dutch phytopathologist Jan C. Zadoks that is widely used in cereal research and agriculture.

Knowing the stages of development of a crop is critical in many management decisions that growers make. They are represented on a scale from 10 to 92. For example, in some countries, nitrogen and herbicide applications must be completed during the tillering stage. In France, the recommendation for the first nitrogen application on wheat is 6 weeks before Z30, with the second application on Z30. Wheat growth regulators are typically applied at Z30. Disease control is most critical in the stem extension and heading stage (Z31, Z32, Z35), in particular as soon as the flag leaf is out (Z37). The crop is also more sensitive to heat or frost at some stages than others (for example, during the meiosis stage the crop is very sensitive to low temperature). Knowing the growth stage of the crop when checking for problems is essential for deciding which control measures should be followed.

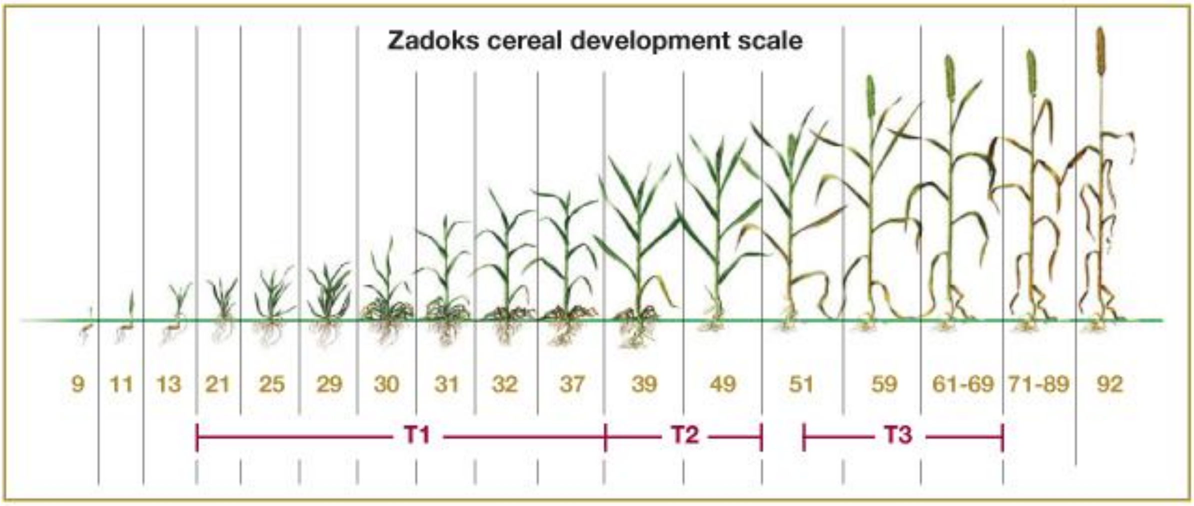
Decimal Code for the Growth Stages of Cereals (Zadoks)

Germination
0 Dry seed
01 Start of imbibition
03 Imbibition complete
05 Radicle emerged from seed
07 Coleoptile emerged from seed
09 Leaf just at coleoptile tip
Seedling growth
10 First leaf through coleoptile
11 First leaf unfolded
12 2 leaves unfolded
13 3 leaves unfolded
14 4 leaves unfolded
15 5 leaves unfolded
16 6 leaves unfolded
17 7 leaves unfolded
18 8 leaves unfolded
19 9 or more leaves unfolded
Tillering
20 Main shoot only
21 Main shoot and 1 tiller
22 Main shoot and 2 tillers
23 Main shoot and 3 tillers
24 Main shoot and 4 tillers
25 Main shoot and 5 tillers
26 Main shoot and 6 tillers
27 Main shoot and 7 tillers
28 Main shoot and 8 tillers
29 Main shoot and 9 or more tillers
Stem Elongation
30 Pseudo stem erection
31 1st node detectable
32 2nd node detectable
33 3rd node detectable
34 4th node detectable
35 5th node detectable
37 Flag leaf just visible
39 Flag leaf ligule/collar just visible
Booting
41 Flag leaf sheath extending
45 Boots just swollen
47 Flag leaf sheath opening
49 First awns visible
Inflorescence emergence
50 First spikelet of inflorescence visible
53 1/4 of inflorescence emerged
55 1/2 of inflorescence emerged
57 3/4 of inflorescence emerged
59 Emergence of inflorescence completed
Anthesis
60 Beginning on anthesis
65 Anthesis half-way
69 Anthesis completed
Milk development
71 Kernel watery ripe
73 Early milk
75 Medium milk
77 Late milk
Dough development
83 Early dough
85 Soft dough
87 Hard dough
Ripening
91 Kernel hard (difficult to divide with thumbnail)
92 Kernel hard (no longer dented with thumbnail)
93 Kernel loosening in daytime
94 Overripe, straw dead and collapsing
95 Seed dormant
96 Viable seed giving 50% germination
97 Seed not dormant
98 Secondary dormancy induced
99 Secondary dormancy lost

This scale follows plant development through 10 primary developmental stages (first digit), sub-divided into secondary growth stages (second digit) to produce a two-digit scale number. The primary stages are defined in the following table.

Zadoks Scale

The primary stages are defined in the following table.



How to Handle Plants

1. Locate the first leaf

The first leaf:

- Is the lowest leaf and generally has a blunt, or rounded tip.
- In older plants, the first leaf may be dead or missing. Look for leaf and sheath remnants at the crown.
- Sheath encloses all later leaves.
- Arises on the opposite side of the plant as the coleoptilar tiller (if present) and the remnants of the coleoptile.

2. Position the plant:

- Hold plant so that the first leaf points to your left and carefully fan-out the leaves and tillers.

3. Locate the main shoot or stem:

- The main shoot or stem

How to Stage Plants

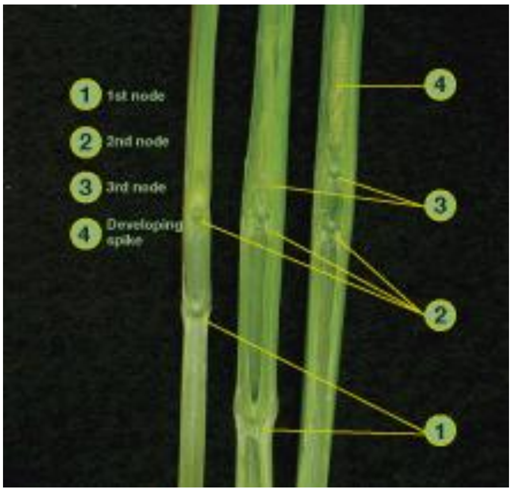
1. **Count the leaves on the main shoot or stem**

- Leaves arise on opposite sides of the main shoot or stem.
- Count the youngest leaf when it is at least one-half the length of the leaf below it.
- When positioned correctly, all leaves on the left side of the main stem are designated with an odd number and on the right side with an even number. The coleoptilar tiller (if present) and the remnants of the coleoptile are also located on the right side of the plant.
- Dead or missing leaves must be counted. Look for leaf and sheath remnants at the crown.

2. **Count the tillers**

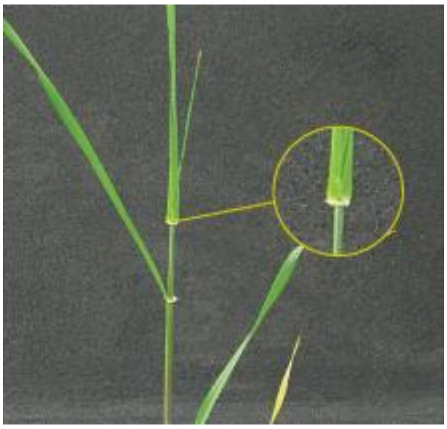
- Each tiller has its own sheath called a prophyll. Each tiller belongs to the main shoot or to other tillers.
- For Zadoks stage determination, only count primary tillers.
- Secondary and tertiary tillers also may be formed, so more than one tiller may emerge from each leaf axil of the main shoot.
- Tillers that emerge after the fifth leaf has emerged are not likely to produce heads and need not be counted.

3. **Count the nodes**



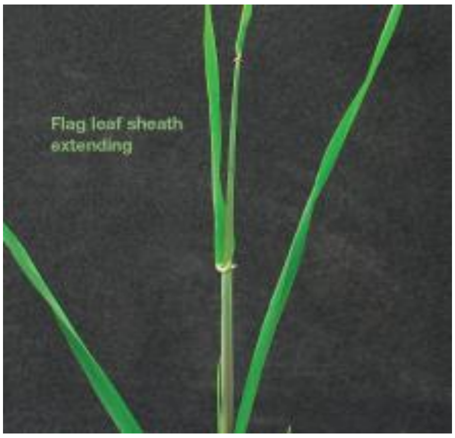
- Nodes can easily be seen or felt on the stem above ground level.
- If no nodes are detected above ground, split the main shoot lengthwise to determine if stem elongation has begun.
- The elongating internode is hollow between the crown and the elevated growing point. In solid stem varieties, the internode is not hollow but nodes are still easily identified.

4. **Has the flag leaf emerged?**



- The flag leaf emerges after at least three nodes are present above the soil surface.
- To confirm flag leaf emergence, split the leaf sheath above the highest node. If the developing head is present and no additional leaves are contained inside, then the last leaf emerged was the flag leaf.
- An alternative method is to crush the stem between your fingers above the second node. If the stem crushes easily above the second node and a third node is felt, then the flag leaf is emerging or has emerged.

5. **Has boot stage begun?**



- Boot stage begins following emergence of the flag leaf collar and continues until heading. The head will be clearly visible inside the sheath of the flag leaf if it is opened up.

6. **Has head emergence and flowering occurred?**

- Heading begins when the first awns or the tip of the head become visible above the flag leaf collar.
- Examine florets to determine if flowering has occurred. Most barley varieties flower prior to head emergence while most wheat varieties flower following head emergence.

7. **Determine grain development stage**

- Grain development begins as soon as the flower has pollinated. Stages include watery ripe, milk, soft dough, hard dough, kernel hard and harvest ripe.