Wheat Field Trial Data Collection Manual

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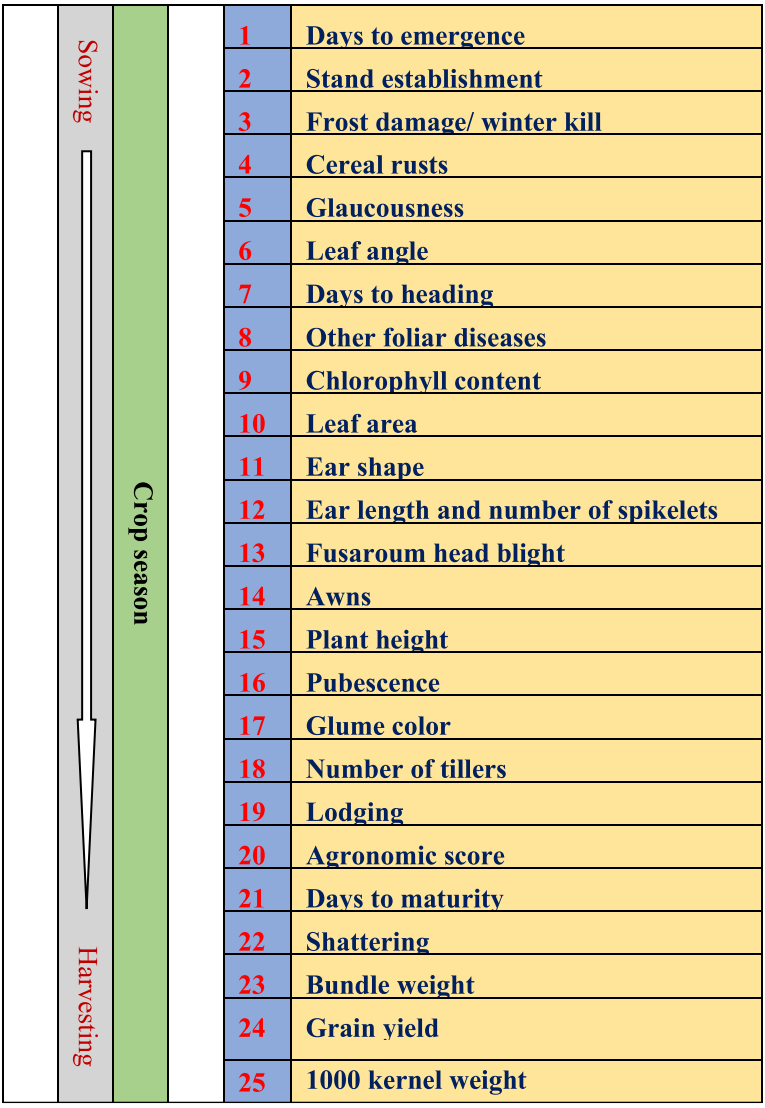
Abbreviations

cm	Centimetre
DH	Days to heading
DM	Days to maturity
FHB	Fusarium Head Blight
g	Grams
GY	Grain Yield
M	Intermediate
MR	Moderately resistant
MS	Moderately Susceptible
PH	Plant height
R	Resistant
TKW	1000-kernel weight

Introduction

Wheat is synonym to food in Afghanistan. The per capita consumption of wheat at about 250 Kg annually in Afghanistan is among the highest in the world. However, country lacks a delivering wheat R&D system as all wheat varieties have been introduced from outside and wheat seed replacement rate at about 5% is one of the lowest in the world. There is need to strengthen whet R&D to boost wheat production in the country. This manual is designed and intended for wheat researchers who are conducting wheat experiments and collecting data on relevant parameters that have been illustrated visually to facilitate smooth and timely collection of data. These parameters are studied in the applied wheat research that fall under the two categories such as qualitative traits and quantitative traits respectively. The major difference between the two types is that while most qualitative traits are of yes or no type or display discontinuous variation, the quantitative traits on the other hand require measurements and display continuous variation. Since applied wheat research needs to be conducted at several locations and several investigators are involved therefore, it becomes imperative that a common or same observation and measurement protocols are adopted in recording the trial data for arriving at valid interpretations.

Recording data



1	Days to emergence
2	Stand establishment
3	Frost damage/ winter kill
4	Cereal rusts
5	Glaucousness
6	Leaf angle
7	Days to heading
8	Other foliar diseases
9	Chlorophyll content
10	Leaf area
11	Ear shape
12	Ear length and number of spikelets
13	Fusaroum head blight
14	Awns
15	Plant height
16	Pubescence
17	Glume color
18	Number of tillers
19	Lodging
20	Agronomic score
21	Days to maturity
22	Shattering
23	Bundle weight
24	Grain yield
25	1000 kernel weight

1. **Days to emergence**: The number of days between sowing and when 50% of seedlings have emerged.

2. **Growth habit**: It will be assessed visually from the attitude of outer leaves and tillers. Depending on the angle formed by the outer leaves and tillers with the imaginary vertical axis, the growth habit will be categorised as shown in the picture (Fig 1) below.

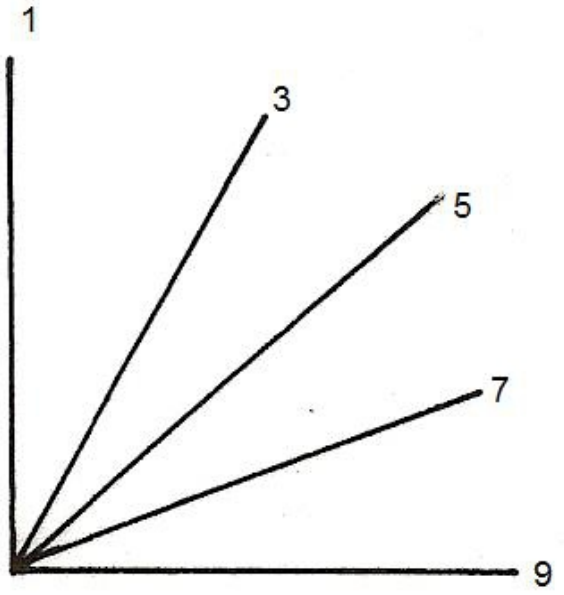


Fig 1. Growth habit. 1: Erect; 3: Semi-erect; 5: Intermediate; 7: Semi- prostrate; 9: Prostrate.

3. **Stand Establishment**: Wheat has high tillering potential which helps it fill gaps. However, any stand reduction should be assessed visually (Fig 2) one week after emergence in % and reported.

Fig 2. Checking stand

4. **Frost damage/ winter kill**: It should be noted along with the stage and date when noted. Seedling damage should be recorded using following 0-9 scale as given in the table 1 below:

Table 1. Damage scale

Scale	**description**
0	No damage
1	Trace damage
3	Slight damage
5	Moderate damage
7	Sever damage
9	Very severe damage

5. **Cereal rusts:** Field notes on rusts describe severity (the percentage of rust infection on the plants) and field response (the type of disease reaction). Severity is recorded as the percent of infection according to the modified Cobb scale (Peterson et al., 1948). Since severity is determined by observation (visual estimates), readings will not be absolutely accurate. A less than 5% severity, often referred to as a "trace" severity,

should be denoted as 1% severity. The intervals used for recording severity are: 0%, 1%, 5%, 10%, 20%, 40%, 60% or 100%.

The field response of a variety or line refers to the type of disease reaction and is recorded by using the following letters:

0 No visible infection on plants

R Resistant – Visible chlorosis or necrosis, no uredia are present

MR Moderately Resistant - Small uredia are present and surrounded by chlorotic or necrotic areas

M Intermediate - Variable sized uredia are present, some with chlorosis, necrosis, or both

MS Moderately Susceptible - Medium sized uredia are present and possibly surrounded by chlorotic areas

S Susceptible - Large uredia are present, generally with little or no chlorosis and no necrosis

Severity and field response readings are recorded at the same time and are combined in the following way:

1R Trace severity with a resistant reaction

5MR 5% severity with a moderately resistant reaction

60S 60% severity with a susceptible reaction

6. **Leaf angle**: The leaf angle at which the leaves are held relative to the vertical axis, and not the stem is an important varietal trait (Fig 3). The trait is most apparent at flag leaf level. This could be erect, horizontal or pendant.

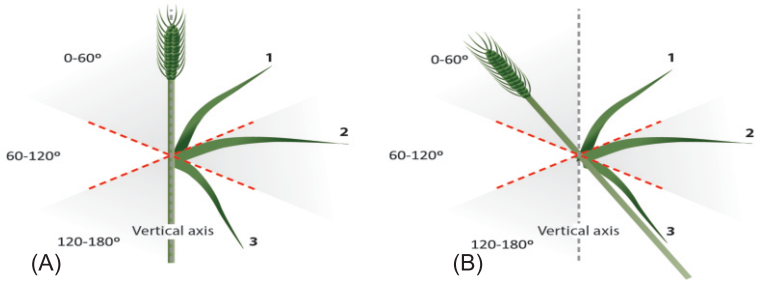


Fig. 3 Score leaf angle relative to the (A) vertical axis, and not (B) the stem.

7. **Days to Heading (DF):** The number of days between germination and heading. A genotype has headed when 50% of the culms have fully emerged spikes (Fig 4).

Fig 4. Fully emerged spike.

8. **Glaucousness:** It appears as a greyish/ white substance on the plant surface (Fig 5). It is a useful trait for varietal characterization.

Fig. 5 Glaucousness on peduncle and spike

9. **Other foliar diseases**: A simple method employing a scale of 0 to 9 is used for other foliar diseases like septoria, helminthosporium, powdery mildew etc. Here 0 (zero) indicates no infection and nine indicates highest severity. The mid-point of the plant is taken as the starting point for this observation.

Grasp the plant at the mid-point. Look for the lesions (Fig 6). If there are lesions at the middle point but not above it, the severity of the disease is taken to be 5. Lesions below mid-point are recorded as 1 to 4 depending on how far up the lesions have progressed. If lesions go above mid-point, the score of 6 to 9 is recorded. See figure 5 for details. If there is infection on spike, draw a slash mark after the leaf score and record the % of the spike that is infected. For example, 5/30 would mean a leaf infection up to the mid-point of plant and 30% of the spike affected.

The following further explains:

0 Free from infection

1 Resistant: A few isolated lesions on lowest leaves only.

2 Resistant: Scattered lesions on the second set of leaves; light infection on the first leaves.

3 Resistant: Light infection of lower third of plant; lowest leaves infected at moderate to severe levels.

4 Moderately Resistant: Moderate infection of lower leaves; scattered light infection extending to the leaf immediately below the mid-point of the plant.

5 Moderately Susceptible: Sever infection of lower leaves; moderate to light infections extending to mid-point of the plant; infection does not extend beyond mid-point of plant.

6 Moderately Susceptible: severe infection of the lower third of the plant; moderate infection on the middle leaves; scattered lesions beyond the mid-point of the plant.

7 Susceptible: Severe infection on lower and middle leaves; infections extending to the leaf below the flag leaf, or trace infection on the flag leaf.

8 Susceptible: Severe infection on lower and middle leaves; moderate to severe infection of upper third of plant; flag leaf infected by more than a trace amount.

9 Severe infection on all leaves; the spike is infected to some degree. Spike infections are scored as to the percentage of the total area covered.

N No scoring possible due to necrosis as a result of other diseases or factors.

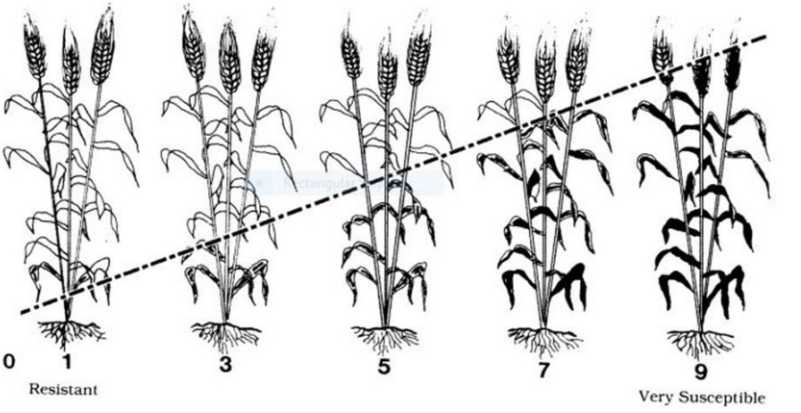


Fig. 6 Guide to scoring other foliar diseases

10. **Chlorophyll Content:** The green photosynthetic pigment absorbs sunlight and transfers this energy to the reaction centre of photosystems. We need to take two measurements, one at the start of heading and another mid-way through grain filling to compare varieties or to study effects of treatments on chlorophyll content. Take three averages of five leaves each per plot. The readings are not absolute values but is a 'chlorophyll concentration index' (CCI). The procedure explained here applies to hand held chlorophyll meter e.g., Minolta SPAD 502 (Fig 7).

Steps & Precautions: 1. Take measurements on fully expanded flag leaves.

2. Ensure that chamber is clean and intact and does not allow any light inside.

3. After turning on the chlorophyll meter, allow the instrument to equilibrate with the ambient temperature for around 10 minutes.

4. Wait until you get N=0 value on screen.

5. Select five flag leaves avoiding outer rows.

6. Leaves must be clean, dry, intact, green and with no disease or damage.

7. Place the leaf in sensor a third to half of the way from the base of the leaf with the upper side facing upward.

8. Hold the pinchers closed until the instrument beeps.

9. Note the CCI reading.

10. Take the average of five readings.

11. Repeat to provide three averages per plot.

11. **Leaf area:** The leaf area intercepts light and pass it on to photosynthetic system for producing photosynthates that ultimately determine yield potential of any variety. Therefore measuring leaf area and relating it with other traits of interest can be interesting studies.

Steps and precaution: 1. Samples should be taken during cooler period so that leaves are not dry and curled up (Fig7).

2. Since leaf area index (LAI) will have a bearing on photosynthesis, anthesis is the right time to compare varieties or investigate effect of variables on LAI.

The automatic planimeter should be allowed to warm up for about 10 minutes.

Use discs of known area to caliberate the equipment.

3. From the quadrat sample, take a sample of 20 fertile culms per plot.

Cut the spikes from the stem at the collar.

Remove all leaf lamina from each culm.

Measure the leaf area using the automatic planimeter.

LAI= (area for 20 culms) * (no. of culms per m^2/20)

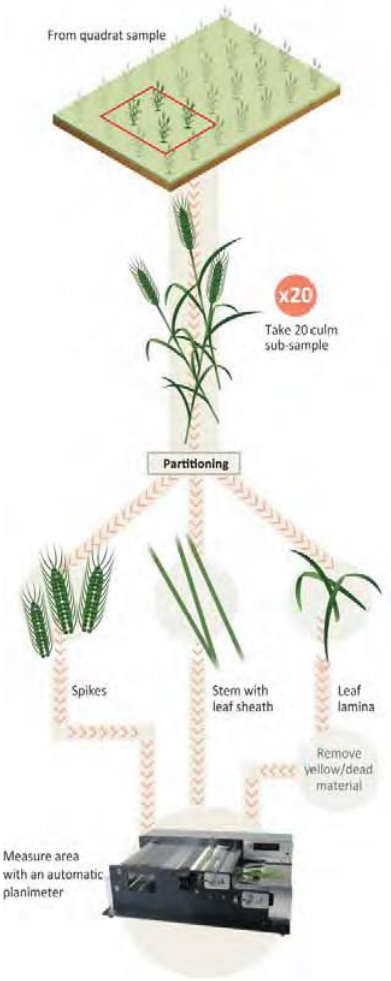


Fig 7. Steps for measuring leaf area.

12. **Ear shape**: Ear can be either tapering with broad base and narrow tip, parallel with almost same width from top to bottom, club shaped with a broader tip or fusiform with a broader middle part as shown in the figure 8.

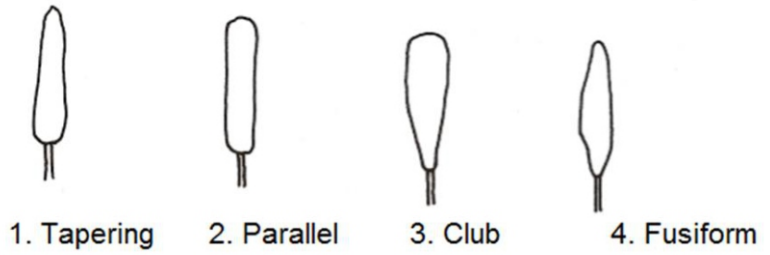


Figure 8 Different shapes of ear

13. **Ear length and number of spikelets per spike**: Average length (cm) of ten randomly selected ears from base of rachis to the tip of the terminal spikelet. Count the number of spikelets per spike for ten random spikes picked up from the main tiller.

14. **Fusarium Head Blight (FHB):** A major disease affecting wheat globally (Fig 9). Visual scoring (Fig 10) may give a general idea. However, if a detailed and precise scoring is required then each affected spike in plants and each spike is to be counted and FHB index may be calculated as explained in Fig 11.

Fig 9. A FHB affected spike.

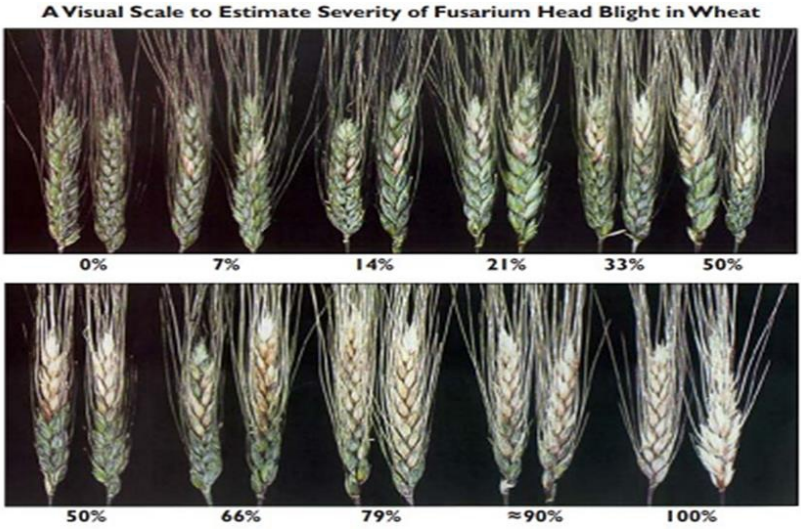
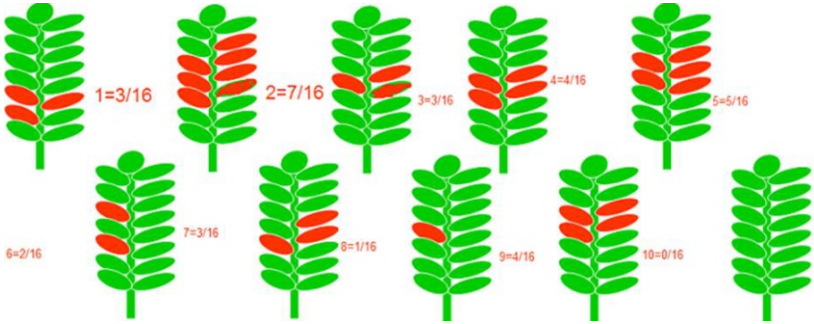


Fig 10. A visual scoring guide for FHB. Reproduced from

https://www.ag.ndsu.edu/ndipm/publications/wheat/documents/pp1095.pdf



FHB Index = (Incidence (%) x Severity (%)) /100= (90X20)/100=1800/100=18

Fig 11. FHB Index calculation

15. **Awns**: Ears may or may not have them. Sometimes very small awns (fig 12) can be present as explained below:

15.1 Absent: No Awns

15.2 Awnlets: Small and sparsely present

15.3 Fully awned

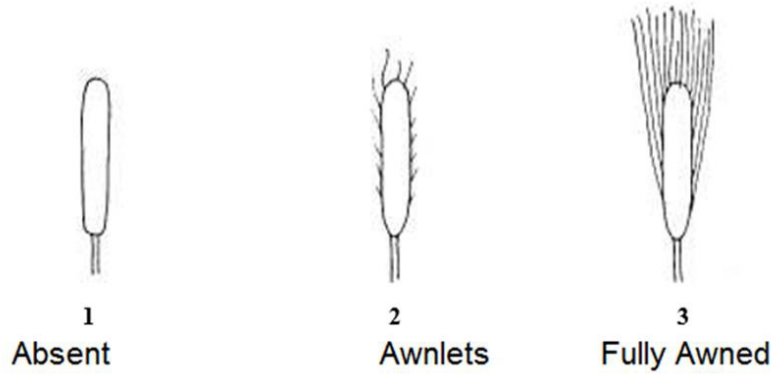


Fig 12. Awns on ears

16. **Plant height (PH):** Length of the main culm (Fig.13) from soil surface to the tip of the spike excluding awns. Record to the nearest centimetre. For plot, it is estimate/ observation of plot canopy. For germplasm or nurseries, take an average of 10 plants.

Fig. 13. Recording Plant height

17. **Pubescence**: It appears as silvery hairs on plant surface (Fig 14). It is an important trait for varietal characterization.

Fig. 14 Pubescent glumes

18. **Number of tillers**: Number of tillers per plant can be counted at flowering time only in space planted nurseries. An average of ten plants can be recroded. In bigger plots, number of fertile tillers per m^2 can be counted using a $1m^2$ quadrat.

19. **Lodging**: The degree of lodging (Fig. 15) should be recorded using a percentage scale. The 0% value indicates fully upright plants and 100% indicates completely lodged plants. Reason for lodging may also be recorded.

Fig. 15 Types of lodging

20. **Agronomic score:** Overall phenotypic impression of test entries can be periodically recorded at various growth stages to assess entries. Consider traits like uniformity, yield potential, disease free, no lodging etc. The following symbols are recommended to record this traits:

√ the entry has an above average phenotype.

√* Good phenotype.

√** Excellent phenotype.

√*** Outstanding phenotype.

If an entry receives no score, it is assumed to be no better than the check.

At the end of the season, these notes help co-operators select the best phenotypes based on their appearance throughout the season. This manner of selection has been very helpful in eliminating less desirable entries, particularly in screening and disease nurseries.

21. **Days to maturity (DM)**: The number of days between germination and physiological maturity. Physiological maturity is achieved when 50% of the spikes are ripe (Fig 16 and 17). See Annexure 1 for a description of major wheat growth stages as per Zadoks scale (Zadoks et al., 1974).

Fig. 16 Physiological maturity (GS87 of Zadoks scale)

Fig. 17. A comparison of peduncles at GS 83, GS 87and GS 93 of Zadoks scale

22. **Shattering**: Shattering is recorded on a percentage scale. The 0% indicates no shattering and 100% indicates complete shattering.

23. **Bundle weight**: The bundle harvested for 11 above may be weighed in grams (g) per plot before thrashing.

24. **Grain Yield (GY)**: Each co-operator should use their own local, experimental plot management practices to harvest these nurseries. To reduce errors due to bird damage and shattering, the nursery should be cut as soon after physiological maturity as possible. Data should be recorded in grams (g) per plot. Please clearly indicate on the data sheets any modifications made in plot sizes or shapes, and the area actually harvested. In bigger plots, border rows may be discarded to remove border effect.

25. **1000 kernel weight (TKW)**: The 1000 grain weight is expressed in grams (g) per 1000 kernels of normal size. Broken and shrivelled grains should not be used. Smaller units (e.g. 100 kernels) can be weighed and then 1000 grain weight can be calculated.

Glossary

Auricle. A lobe at the base of a leaf; from the Latin auris meaning "ear" (hence a lobe).

Anther. A saclike structure of the male part of a flower in which the pollen is formed.

Anthesis. Flowering. Usually taken to mean the time at which pollen is shed.

Awns. A slender, often long, appendage extending from the tip of the lemma; occasionally referred to as the "beards" of wheat and barley.

Axil. The space between a leaf (or tiller) and the stem it is attached to. A tiller originates as a bud in the axil of a leaf.

Chlorosis: Yellowing of leaves due to reduction in chlorophyll content.

Coleoptile. A sheath which protects the first leaf and shoot apex as they emerge to the surface during germination.

Culm: Above soil stem.

Flag leaf: The spike bearing leaf, the top most leaf e.g. in wheat.

Floret. An individual flower of a cereal. Each floret has three anthers containing pollen and an ovary which, when fertilised may form a grain. Up to ten florets may form in each spikelet, but generally only 2-4 form grains.

Flowering: A genotype has flowered when 50% of the culms have fully emerged spikes.

Fruit. A mature ovary which includes the ovule (seed), in addition to the ovary wall (pericarp) that surrounds the seed.

Germination: The intake of water by a seed leading to an increase in metabolism and elongation finally resulting the formation of new tissues or emergence of coleiptile radical in case of wheat.

Glumes. The outer chaffy bracts that enclose the wheat spikelet.

Infection: Invasion of wheat by a disease causing agent e.g., a rust causing fungus.

Internode. The stem tissue between any two nodes. In cereals, the elongation of these tissues is responsible for stem elongation and ear exertion.

Kernel: Seed

Lemma. One of the thin bracts of a grass floret enclosing the caryopsis that is located on the side nearest the embryo and opposite the rachilla (see also palea).

Lesion: A wound or a diseased area.

Necrosis: Death of a cell or group of cells while still part of the living plant.

Node. The part of the stem from which a leaf or root may arise

Ovary. The part of the female part of the flower containing the ovule.

Ovule. The structure within the ovary of the flower that becomes the seed following fertilisation and development.

Peduncle: The stalk of a flower or of inflorescence.

Phenotype: A measurable or observable property of an organism or sum total of all those properties/ characters.

Qualitative character: A character in which variation is discontinuous. The opposite is quantitative character which shows continuous variation.

Raceme: Inflorescence with its main axis having flowers.

Rachilla: The axis in the centre of a grass spikelet.

Rachis: The main axis of an inflorescence. For example, in wheat.

Sessile: Stalkless.

Spike: A raceme of sessile flowers. A wheat ear.

Spikelet: One of the units of the inflorescence of a grass (e.g., of wheat).

Teleutospore: A thick walled spore formed by rust fungus towards the end of the growing season. These may remain dormant for some time and then germinate to cause another cycle of infection.

Trait: Alternative form of a character. For example, grain colour is a character but white or red grain colour are two traits.

Urediospore: A spore formed by rust fungi wheat growing vigorously producing mycelium which may produce more urediospores or later in the season teleutospores.

References

Peterson, RF, Campbell AB & Hannah AE. 1948. A diagrammatic scale for estimating rust intensity of leaves and stems of cereals. Canadian J. Res. Section C26: 496-500.

Zadoks C, Chang TT & Konzak CF. 1974. A decimal code for the growth stages of cereals. Weed Res. 14: 415-421.

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Annexure I

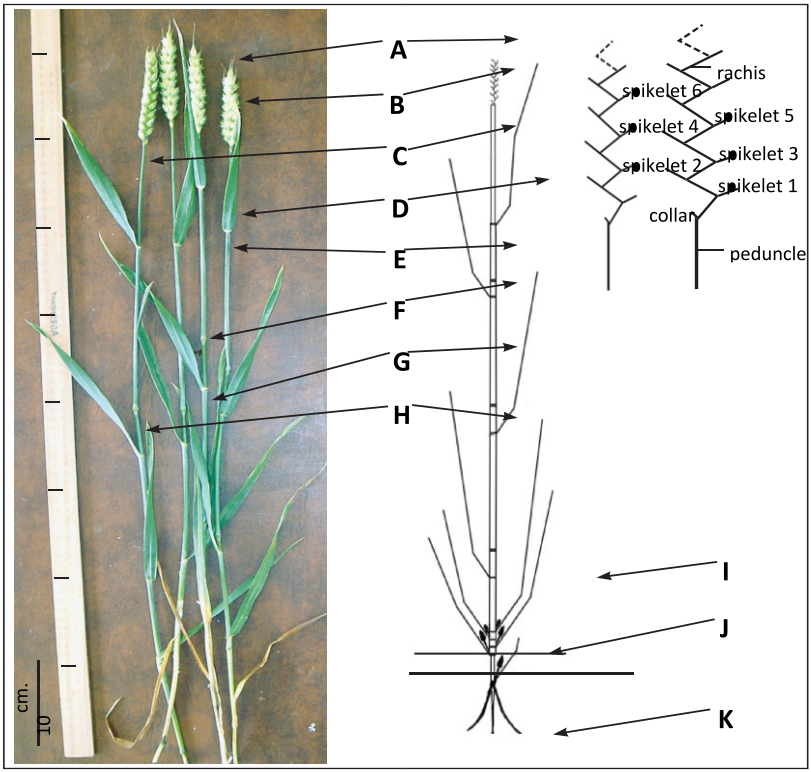
Main growth stages (GS) as per Zadoks scale

GS	Description
Seedling	
00	Dry Seed
10	First leaf through coleoptile
13	3 leaves unfolded
Tillering	
20	Main shoot only
21	Main shoot and one tiller
25	Main shoot and 5 tillers
Stem elongation	
37	Flag leaf just visible
Booting	
41	Flag leaf sheath extending
43	Boot just visibly swollen
45	Boot swollen
47	Flag leaf sheath opening
49	First Awns visible
Heading	
55	½ of head emerged
59	Head emergence complete
Flowering	
61	Flowering start
65	Flowering half complete
	Kernel and 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
89	Late hard dough
Ripening	
91	Kernel hard
93	Kernel loosening
94	Overripe, straw dead and collapsing

Annexure II

Wheat Plant parts (A: Awns; B: Spike; C: Peduncle; D: Flag leaf; E: Leaf sheath; F: Node; G: Internode; H: Stem; I: Lower leaves; J: Crown; K: Roots)



Annexure III

Different parts of a spikelet