

Agriculture

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Decimal Growth Scale of Cereals

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Accurate assessment of growth stage is important because the cereal plant's response to herbicide, growth regulator or fertiliser application depends on its stage of development.

The Decimal (or Zadoks) growth scale of cereals is recognised internationally for research, advisory work and farm practice. In Europe the decimal scale is already used in farming publications and the labelling of agrochemicals; and its use in Australia has been endorsed by the Australian Weeds Committee.

The Decimal scale

The Decimal growth scale is based on ten principal growth stages labelled 0 to 9. These sub-divide the cereal plant life cycle into 10 major stages:

0 Germination

1 Seedling growth

2 Tillering

3 Stem elongation

4 Booting

5 Ear emergence

6 Flowering

7 Milk development

8 Dough development

9 Ripening

Each primary growth stage is then sub-divided into 10 secondary stages extending the scale from 00 to 99 (see Growth Scale Table).

Early growth stages of seedling growth (1) tillering (2) and stem elongation (3) - which are the most important commercially - are described exactly by counting the organs on the plant. For example, a "one-leaf" plant is scored as 11 and a "three-leaf" as 13. Similarly, one tiller is 21, four tillers 24, one node or joint detectable in the stem 31, and so on.

Growth scores are concurrent. Because more than one growth process is going on at the same time, for example leaves emerging and tillers forming, more than one growth score may apply at the same time. For example a plant may be scored as 17 (seven leaves on the main shoot), 24 (four tillers) and 31 (one node detectable). Another example is when drought affected plants flower before the head has fully emerged from the boot. Such a plant might be scored 53 ($\frac{1}{4}$ inflorescence emerged) and 65 (flowering).

Although confusing at first, the concurrent scores do accurately reflect the current growth stage of the plant.

Using the Decimal scale

Like all growth scales the Decimal scale includes certain conventions and requires some practice before the user becomes fully familiar with it.

The Decimal scale is based on observation of an individual plant, not the general appearance of a crop. It therefore requires the user to either choose a plant as representative of the crop; or to sample the crop, score the chosen plants and determine the average growth stage.

Seedling growth: 10 to 19

After crop emergence, seedling growth is scored by counting the number of emerged leaves. The rules for counting leaves are:

- count leaves on the main stem only
- a leaf is counted as emerged when either its ligule has emerged from the sheath of the preceding leaf, or when the tip of the next leaf is visible.

It is useful to sub-divide the scale further by scoring the youngest leaf in tenths by judging its size relative to the preceding leaf. A score of 11.5 therefore, corresponds to one-and-a-half leaves and 13.9 is very close to the four fully-emerged-leaf stage.

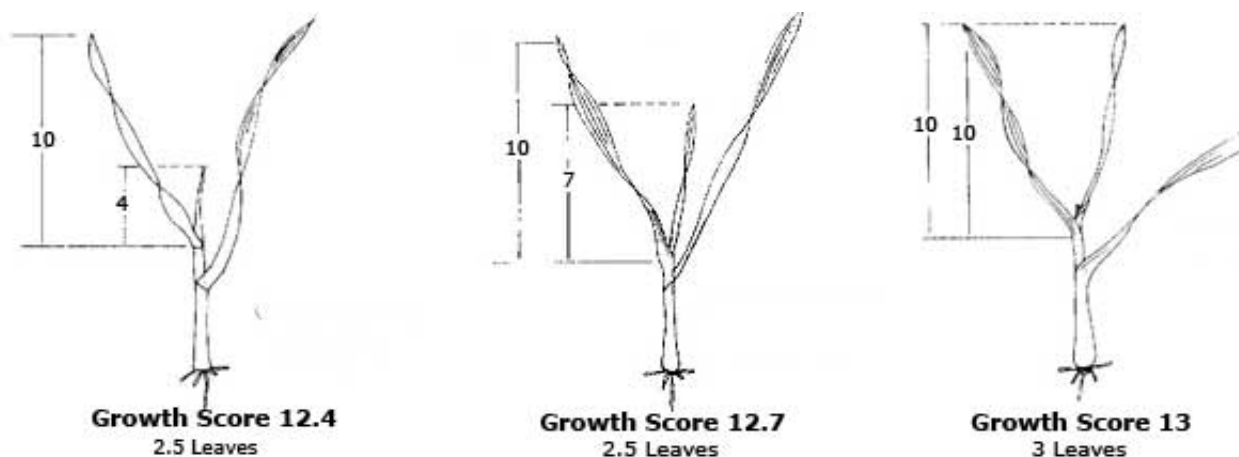


Fig 1. Counting leaves

Tillering: 20 to 29

The first tiller usually appears in wheat at growth stage 13 to 14 - when the plant has three or four leaves emerged. Tillering is scored by:

- counting tillers as soon as they emerge from the sheath of the subtending leaf
- counting only tillers, not the main stem.

Tillers originate from small buds where each leaf joins the stem. These grow and eventually emerge from between the leaf sheath and the stem. Occasionally an additional tiller may grow from the seed; this is known as a tiller and should also be counted.

Stem elongation: 30 to 39

Stem extension or "jointing" is the process by which the ear - originally formed as a microscopic structure between growth stages 14 and 16 - is pushed to the top of the crop canopy.

The stem originally consists of "nodes" or "joints" (where the leaves join the stem) and "internodes" all closely pushed together and only a few millimetres long.

When stem extension begins, an internode in the middle of the stack expands to several centimetres long and the node above it swells and hardens to form the first joint. This process is repeated by other internodes above the first until eventually the ear emerges from the boot.

Score a node as present when a thickening can be felt 10 to 50 mm from the ground.

As stem extension occurs before there is any significant thickening of the node, the node can only be detected by stripping back the leaves or splitting the stem with a blade. This is a major point of confusion and whether a node is detected by feel or dissection should be made clear.

Anthesis (flowering): 60 to 69

Anthesis means the opening of the floret to shed its pollen and be fertilised. Florets usually open in the early morning and then for less than 30 minutes. Anthesis is usually scored however, by the presence of the emerged anthers that have already shed pollen. This occurs first in the middle of the ear (stage 65) and spreads towards the top and base.

If moisture is lacking, head emergence may cease temporarily, or flower opening and anther extrusion may not occur.

Milk and dough development: 70 to 89

Grain development is not described well by the Decimal or any other general growth scale and requires subjective assessment of the amount of solids in the milk and the stiffness of the dough.

Grain growth for seven to 14 days after fertilisation is mainly growth of the maternal pericarp - the ovary wall containing a watery fluid. This is scored as kernel watery ripe (71). Only then does starch deposition begin and the ratio of solids to liquid determines the early, medium and late milk stages. Dough development follows when no liquid remains.

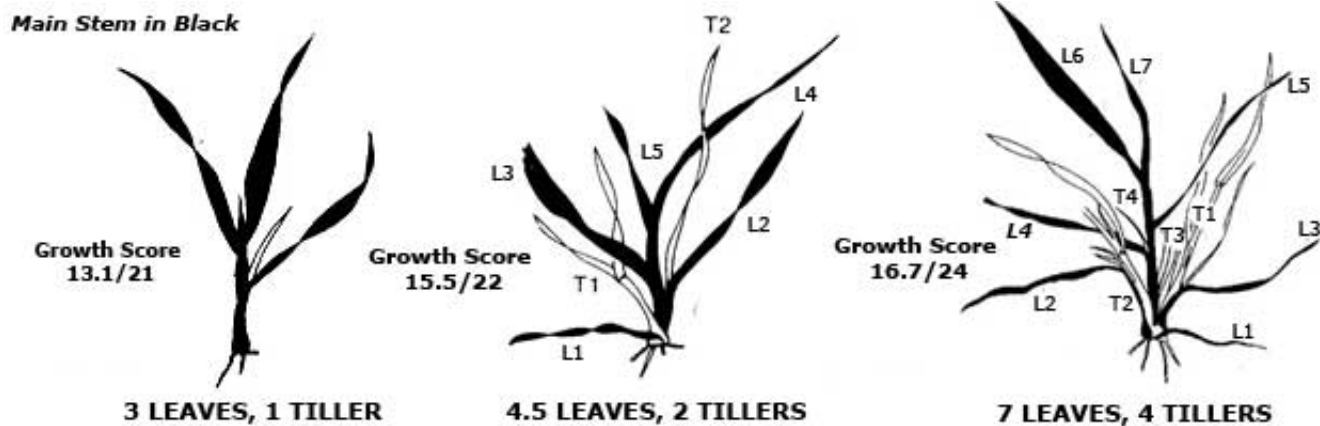


Fig 2. Counting the leaves

Ripening: 90 to 99

Stage 92 can be taken as grain maturity and stage 93 as harvest ripe. These may be only a day or two apart where conditions are hot and dry; or several weeks apart in cool moist environments.

Stages 94 to 99 are not relevant to Australia.

Why the scale should be used

Use of the Decimal growth scale may appear to be an unwelcome complexity to add to the problems of managing a crop. Nevertheless, there are two vital reasons for introducing it:

- To improve and standardise communication between people in all sectors of agriculture. It is much more informative for the plant pathologist to know that the diseased crop was at growth stage 39- flag leaf ligule visible - than to be told that it was at "jointing".
- More accurate description of growth stage is required as advice on crop management is increasingly given in terms of growth stage rather than calendar time. How much better is the advice available on herbicide tolerance when the growth stage is given as 24/31 rather than a vague description of "mid- to late tillering" or "seven weeks from sowing".

The Decimal Growth Scale

0. Germination	1 Seedling growth	2 Tillering
00 Dry seed	10 First leaf through coleoptile	20 Main shoot only
01 Start of imbibition (water absorption)	11 First leaf emerged	21 Main shoot and 1 tiller
02 -	12 2 leaves emerged	22 Main shoot and 2 tillers
03 Imbibition complete	13 3 leaves emerged	23 Main shoot and 3 tillers
04 -	14 4 leaves emerged	24 Main shoot and 4 tillers
05 Radicle (root) emerged from		25 Main shoot and 5 tillers

caryopsis (seed)	15 5 leaves emerged	26 Main shoot and 6 tillers
06 -	16 6 leaves emerged	27 Main shoot and 7 tillers
07 Coleoptile (shoot) emerged from	17 7 leaves emerged	28 Main shoot and 8 tillers
caryopsis	18 8 leaves emerged	29 Main shoot and 9 or more tillers
08 -	19 9 or more leaves	
09 Leaf just at coleoptile tip	emerged	

3 Stem elongation

30 Pseudostem (leaf sheath) erection
31 First node detectable
32 2nd node detectable
33 3rd node detectable
34 4th node detectable
35 5th node detectable
36 6th node detectable
37 Flag leaf just visible
38 -
39 Flag leaf ligule just visible

4 Booting

40 -
41 Flag leaf sheath extending
42 -
43 Boots just visibly swollen
44 -
45 Boots swollen
46 -
47 Flag leaf sheath opening
48 -
49 First awns visible

5 Inflorescence (ear/panicle) emergence

50 -
51 First spikelet of inflorescence just visible
52 -
53 Inflorescence $\frac{1}{4}$ emerged
54 -
55 Inflorescence $\frac{1}{2}$ emerged
56 -
57 Inflorescence $\frac{3}{4}$ emerged
58 -
59 Emergence of inflorescence completed

6 Anthesis (flowering)

60 -
61 Beginning of anthesis
62 -
63 -
64 -
65 Anthesis half-way
66 -
67 -
68 -
69 Anthesis complete

7 Milk development

70 -
71 Caryopsis (kernal) water ripe
72 -
73 Early milk
74 -
75 Medium milk
76 -
77 Late milk
78 -
79 -

8 Dough development

80 -
81 -
82 -
83 Early dough
84 -
85 Soft dough
86 -
87 Hard dough
88 -
89 -

9 Ripening

90 -
91 Caryopsis hard (difficult to divide)
92 Caryopsis hard (not dented by thumbnail)

- 93 Caryopsis loosening in daytime
- 94 Over-ripe 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

Acknowledgements

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