Compendium of Growth Stage Identification Keys for Mono- and Dicotyledonous Plants

Extended BBCH scale

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General Scale

Cereals, Rice, Maize

Oilseed rape, Faba bean, Sunflower

Beta beets

Potato

Fruits

Citrus

Grapevine

Soybean, Cotton, Peanuts

Hop

Vegetable crops I

Vegetable crops II

Weeds

BBCH-Publications

The extended BBCH-scale

Hack et al., 1992

The extended BBCH-scale is a system for a uniform coding of phenologically similar growth stages of all mono- and dicotyledonous plant species.
It results from teamwork between the German Federal Biological Research Centre for Agriculture and Forestry (BBA), the German Federal Office of Plant Varieties (BSA), the German Agrochemical Association (IVA) and the Institute for Vegetables and Ornamentals in Grossbeeren/Erfurt, Germany (IGZ). The decimal code, which is divided into principal and secondary growth stages, is based on the well-known cereal code developed by ZADOKS et al. (1974) in order to avoid major changes from this widely used phenological key.The abbreviation **BBCH** derives from **B**iologische **B**undesanstalt, Bundessortenamt and **CH**emical industry.

The basic principles of the scale

- The general scale forms the framework within which the individual scales are developed. It can also be used for those plant species for which no special scale is currently available.
- Similar phenological stages of each plant species are given the same code.
- For each code, a description is given, and for some important stages, drawings are included.
- For the description of the phenological development stages, clear and easily recognised (external) morphological characte-ristics are used.
- Except where stated otherwise, only the development of the main stem is taken into consideration.
- The growth stages refer to representative individual plants within the crop stand. Crop stand characteristics may also be considered.
- Relative values relating to species- and/or variety-specific ultimate sizes are used for the indication of sizes.
- The secondary growth stages 0 to 8 correspond to the respective ordinal numbers or percentage values. For example stage 3 could represent: 3rd true leaf, 3rd tiller, 3rd node or 30% of the final length or size typical of the species or 30% of the flowers open.
- Post harvest or storage treatment is coded **99**.
- Seed treatment before planting is coded **00**.

Organisation of the scale

The entire developmental cycle of the plants is subdivided into ten clearly recognizable and distinguishable longer-lasting developmental phases. These **principal growth stages** are described using numbers from 0 to 9 in ascending order (see Figures 1a and b). The principal growth stages are described in Table 1. Owing to the very many different plant species there may be shifts in the course of the development or certain stages may even be omitted.

The principal growth stages need not proceed in the strict sequence defined by the ascending order of the figures, but can occasionally also proceed in parallel.

Table 1:

Principal growth stages

Stage	Description
0	Germination / sprouting / bud development
1	Leaf development (main shoot)
2	Formation of side shoots / tillering
3	Stem elongation or rosette growth / shoot development (main shoot)
4	Development of harvestable vegetative plant parts or vegetatively propagated organs / booting (main shoot)
5	Inflorescence emergence (main shoot) / heading
6	Flowering (main shoot)
7	Development of fruit
8	Ripening or maturity of fruit and seed
9	Senescence, beginning of dormancy

If two or more principal growth stages proceed in parallel, both can be indicated by using a diagonal stroke (example 16/22). If only one stage is to be indicated, either the more advanced growth stage must be chosen or the principal growth stage of particular interest, depending upon the plant species.
The principal growth stages alone are not sufficient to define exactly application or evaluation dates, since they always describe time spans in the course of the development of a plant.
Secondary stages are used if **points of time** or steps in the plant development must be indicated precisely. In contrast to the principal growth stages they are defined as short developmental steps characteristic of the respective plant species, which are passed successively during the respective principal growth stage. They are also coded by using the figures 0 to 9.
The combination of figures for the principal and the secondary stages, results in the two-digit code.
The two-digit code is a scale which offers the possibility of precisely defining all phenological growth stages for the majority of plant species.
Only in the case of some plant species (e.g. cucumber, onion, potato, soybean, tomato) is further subdivision necessary within a principal growth stage beyond that possible using the secondary stages from 0 to 9.
For these cases a three-digit scale is presented alongside the two-digit scale. This involves the inclusion of the so-called **mesostage** between the principal and the secondary stage, which provides a further subdivision with figures **0** and **1** describing the development on the **main stem** and figures **2** to **9**

that of the side shoots **2nd** to **9th order** (see Figures 1a and b). In this way up to 19 leaves can be counted on the main stem or the branching can be described.

The BBCH-scales allow the comparison of individual codes only within one principal growth stage: an arithmetically greater code indicates a plant at a later growth stage. Sorting codes into numerical order therefore allows a listing in order of the stage of plant development.

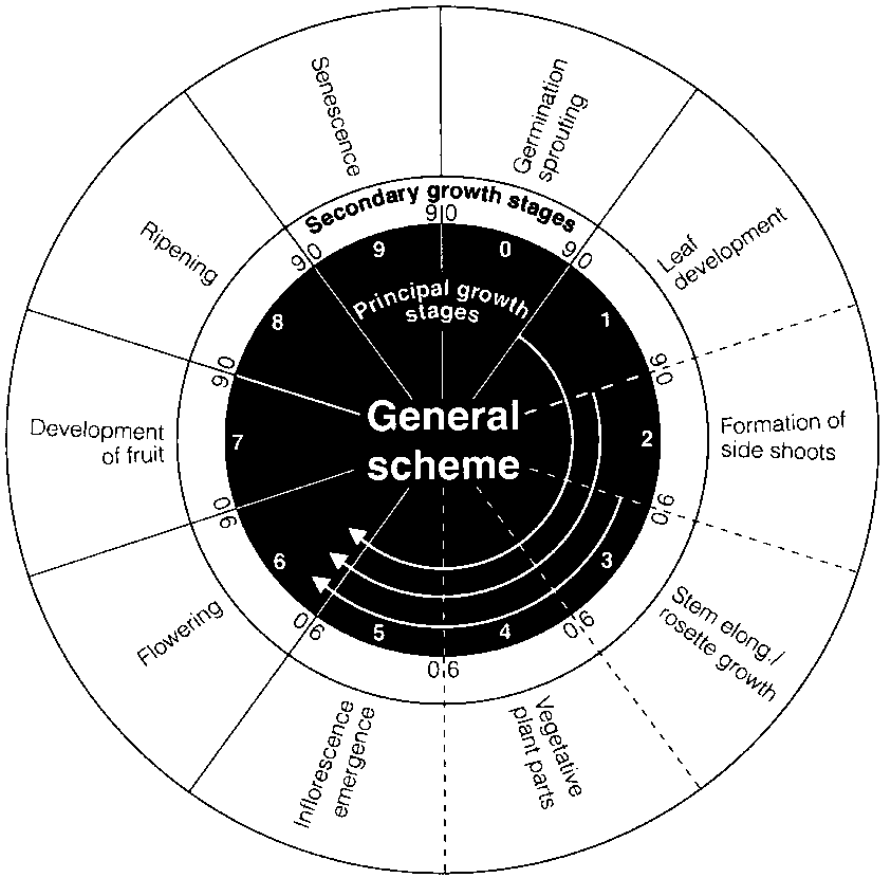
The time span of certain developmental phases of a plant can be exactly defined and coded by indicating two stages. For this purpose two codes are connected with a hyphen. Thus, for instance, the code 51–69 describes the developmental phase from the appearance of the first inflorescence or flower buds until the end of flowering. This allows the computer-supported monitoring of crop stands.

For a uniform coding which covers the maximum number of plant species, it is necessary to use primarily phenological criteria rather than homologous or analogous stages. Thus, for instance, germination of plants from true seed and sprouting from buds are classified in one principal growth stage, the principal growth stage 0, even though they are completely different biological processes.

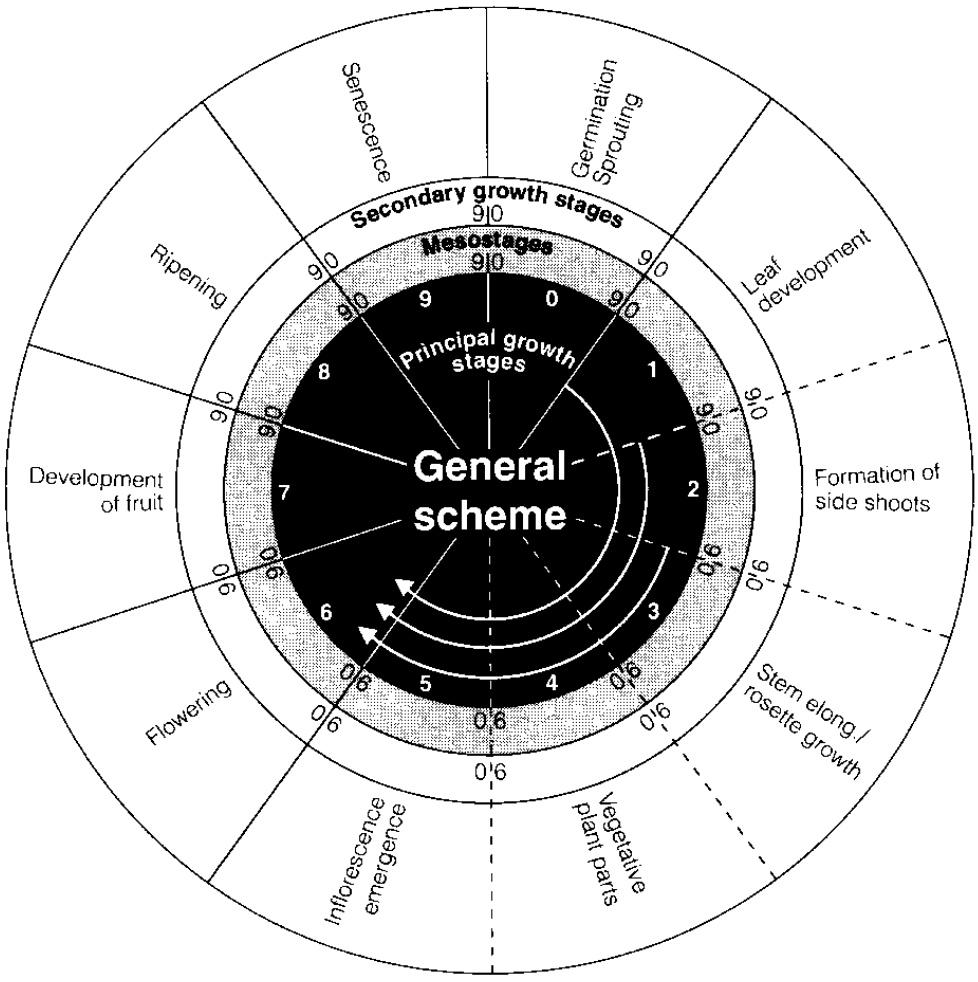
In case of the BBCH-scales the descriptions are based on the actual characteristic features of the individual plant. If the scales are used for the definition of the development stage of a plant stand, the description should apply to at least 50% of the plants.

Greater differences in the course of the development of different plant groupshave to be taken into consideration for the description of the general scale (see 1.2). This problem is dealt with by offering several definitions for one specific stage wherever the formulation of a uniform text is impossible. The following letters show to which plant group the respective definition refers.

Figures 1a and b:
Subdivision of the developmental cycle of plants into principal and secondary stages (a) and into principal, meso- and secondary stages (b). The mesostages are inserted between the principal and the secondary stages. Modified according to a draft by A. Witzenberger.


Secondary growth stages
Principal growth stages
General scheme
Germination sprouting
Leaf development
Formation of side shoots
Stem elong./ rosette growth
Vegetative plant parts
Inflorescence emergence
Flowering
Development of fruit
Ripening
Senescence

a


Secondary growth stages
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Principal growth stages
General scheme
Germination Sprouting
Leaf development
Formation of side shoots
Stem elong./ rosette growth
Vegetative plant parts
Inflorescence emergence
Flowering
Development of fruit
Ripening
Senescence

b

The extended BBCH-scale, general Hack et al., 1992

D = Dicotyledons
M = Monocotyledons
V = Development from vegetative parts or propagated organs.
G = Gramineae
P = Perennial plants

No code letter is used if the description applies to all groups of plants.

Code		Description
Principal growth stage 0: Germination, sprouting, bud development		
00		Dry seed (seed dressing takes place at stage 00)
	P, V	Winter dormancy or resting period
01		Beginning of seed imbibition;
	P, V	Beginning of bud swelling
03		Seed imbibition complete;
	P, V	End of bud swelling
05		Radicle (root) emerged from seed;
	P, V	Perennating organs forming roots
06		Elongation of radicle, formation of root hairs and/or lateral roots
07	G	Coleoptile emerged from caryopsis;
	D, M	Hypocotyl with cotyledons or shoot breaking through seed coat;
	P, V	Beginning of sprouting or bud breaking
08	D	Hypocotyl with cotyledons growing towards soil surface;
	P, V	Shoot growing towards soil surface
09	G	Emergence: Coleoptile breaks through soil surface;
	D, M	Emergence: Cotyledons break through soil surface (except hypogeal germination);
	D, V	Emergence: Shoot/leaf breaks through soil surface;
	P	Bud shows green tips
Principal growth stage 1: Leaf development (main shoot)		
10	G	First true leaf emerged from coleoptile;
	D, M	Cotyledons completely unfolded;
	P	First leaves separated
11		First true leaf, leaf pair or whorl unfolded;
	P	First leaves unfolded
12		2 true leaves, leaf pairs or whorls unfolded
13		3 true leaves, leaf pairs or whorls unfolded
1 .		Stages continuous till . . .
19		9 or more true leaves, leaf pairs or whorls unfolded

The extended BBCH-scale, general Hack et al., 1992

Code		Description
Principal growth stage 2: Formation of side shoots/tillering		
21		First side shoot visible;
	G	First tiller visible
22		2 side shoots visible;
	G	2 tillers visible
23		3 side shoots visible;
	G	3 tillers visible
2 .		Stages continuous till . . .
29		9 or more side shoots visible;
	G	9 or more tillers visible
Principal growth stage 3: Stem elongation or rosette growth, shoot development (main shoot)		
31		Stem (rosette) 10% of final length (diameter);
	G	1 node detectable
32		Stem (rosette) 20% of final length (diameter);
	G	2 nodes detectable
33		Stem (rosette) 30% of final length (diameter);
	G	3 nodes detectable
3 .		Stages continuous till . . .
39		Maximum stem length or rosette diameter reached;
	G	9 or more nodes detectable
Principal growth stage 4: Development of harvestable vegetative plant parts or vegetatively propagated organs/booting (main shoot)		
40		Harvestable vegetative plant parts or vegetatively propagated organs begin to develop
41	G	Flag leaf sheath extending
43		Harvestable vegetative plant parts or vegetatively propagated organs have reached 30% of final size;
	G	Flag leaf sheath just visibly swollen (mid-boot)
45		Harvestable vegetative plant parts or vegetatively propagated organs have reached 50% of final size;
	G	Flag leaf sheath swollen (late-boot)
47		Harvestable vegetative plant parts or vegetatively propagated organs have reached 70% of final size;
	G	Flag leaf sheath opening
49		Harvestable vegetative plant parts or vegetatively propagated organs have reached final size;
	G	First awns visible

The extended BBCH-scale, general Hack et al., 1992

Code		Description
Principal growth stage 5: Inflorescence emergence (main shoot) / heading		
51		Inflorescence or flower buds visible;
	G	Beginning of heading
55		First individual flowers visible (still closed);
	G	Half of inflorescence emerged (middle of heading)
59		First flower petals visible (in petalled forms);
	G	Inflorescence fully emerged (end of heading)
Principal growth stage 6: Flowering (main shoot)		
60		First flowers open (sporadically)
61		Beginning of flowering: 10% of flowers open
62		20% of flowers open
63		30% of flowers open
64		40% of flowers open
65		Full flowering: 50% of flowers open, first petals may be fallen
67		Flowering finishing: majority of petals fallen or dry
69		End of flowering: fruit set visible
Principal growth stage 7: Development of fruit		
71		10% of fruits have reached final size or fruit has reached 10% of final size[1]
	G	Caryopsis watery ripe
72		20% of fruits have reached final size or fruit has reached 20% of final size[1]
73		30% of fruits have reached final size or fruit has reached 30% of final size[1]
	G	Early milk
74		40% of fruits have reached final size or fruit has reached 40% of final size[1]
75		50% of fruits have reached final size or fruit has reached 50% of final size[1]
	G	Milky ripe, medium milk
76		60% of fruits have reached final size or fruit has reached 60% of final size[1]
77		70% of fruits have reached final size or fruit has reached 70% of final size[1]
	G	Late milk
78		80% of fruits have reached final size or fruit has reached 80% of final size[1]
79		Nearly all fruits have reached final size[1]

[1] This stage is not used, if the main fruit growth happens in principal growth stage 8

The extended BBCH-scale, general Hack et al., 1992

Code		Description
Principal growth stage 8: Ripening or maturity of fruit and seed		
81		Beginning of ripening or fruit colouration
85		Advanced ripening or fruit colouration;
	G	Dough stage
87		Fruit begins to soften (species with fleshy fruit)
89		Fully ripe: fruit shows fully-ripe colour, beginning of fruit abscission
Principal growth stage 9: Senescence, beginning of dormancy		
91	P	Shoot development completed, foliage still green
93		Beginning of leaf-fall
95		50% of leaves fallen
97		End of leaf fall, plants or above ground parts dead or dormant;
	P	Plant resting or dormant
99		Harvested product (post-harvest or storage treatment is applied at stage 99)

The extended BBCH-scale, for specific crops

Cereals Witzenberger et al., 1989; Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of cereals
(wheat = *Triticum* sp. L., barley = *Hordeum vulgare* L., oat = *Avena sativa* L., rye = *Secale cereale* L.)

Code	Description
Principal growth stage 0: Germination	
00	Dry seed (caryopsis)
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from caryopsis
06	Radicle elongated, root hairs and/or side roots visible
07	Coleoptile emerged from caryopsis
09	Emergence: coleoptile penetrates soil surface (cracking stage)
Principal growth stage 1: Leaf development[1, 2]	
10	First leaf through coleoptile
11	First leaf unfolded
12	2 leaves unfolded
13	3 leaves unfolded
1 .	Stages continuous till . . .
19	9 or more leaves unfolded
Principal growth stage 2: Tillering[3]	
20	No tillers
21	Beginning of tillering: first tiller detectable
22	2 tillers detectable
23	3 tillers detectable
2 .	Stages continuous till . . .
29	End of tillering. Maximum no. of tillers detectable

[1] A leaf is unfolded when its ligule is visible or the tip of the next leaf is visible
[2] Tillering or stem elongation may occur earlier than stage 13; in this case continue with stages 21
[3] If stem elongation begins before the end of tillering continue with stage 30

Cereals Witzenberger et al., 1989; Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of cereals

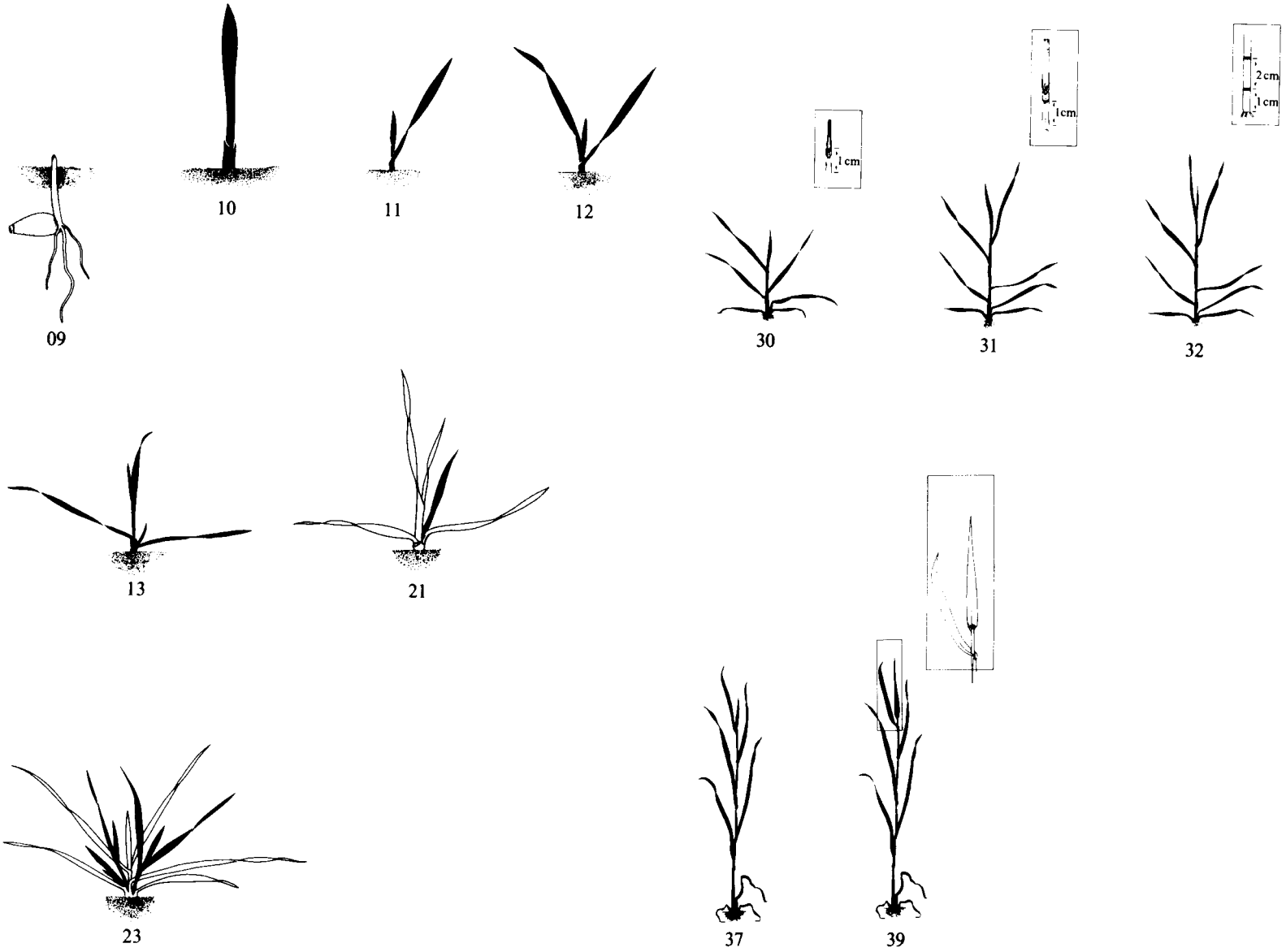
Code	Description
Principal growth stage 3: Stem elongation	
30	Beginning of stem elongation: pseudostem and tillers erect, first internode begins to elongate, top of inflorescence at least 1 cm above tillering node
31	First node at least 1 cm above tillering node
32	Node 2 at least 2 cm above node 1
33	Node 3 at least 2 cm above node 2
3 .	Stages continuous till . . .
37	Flag leaf just visible, still rolled
39	Flag leaf stage: flag leaf fully unrolled, ligule just visible
Principal growth stage 4: Booting	
41	Early boot stage: flag leaf sheath extending
43	Mid boot stage: flag leaf sheath just visibly swollen
45	Late boot stage: flag leaf sheath swollen
47	Flag leaf sheath opening
49	First awns visible (in awned forms only)
Principal growth stage 5: Inflorescence emergence, heading	
51	Beginning of heading: tip of inflorescence emerged from sheath, first spikelet just visible
52	20% of inflorescence emerged
53	30% of inflorescence emerged
54	40% of inflorescence emerged
55	Middle of heading: half of inflorescence emerged
56	60% of inflorescence emerged
57	70% of inflorescence emerged
58	80% of inflorescence emerged
59	End of heading: inflorescence fully emerged
Principal growth stage 6: Flowering, anthesis	
61	Beginning of flowering: first anthers visible
65	Full flowering: 50% of anthers mature
69	End of flowering: all spikelets have completed flowering but some dehydrated anthers may remain
Principal growth stage 7: Development of fruit	
71	Watery ripe: first grains have reached half their final size
73	Early milk
75	Medium milk: grain content milky, grains reached final size, still green
77	Late milk

Cereals Witzenberger et al., 1989; Lancashire et al., 1991

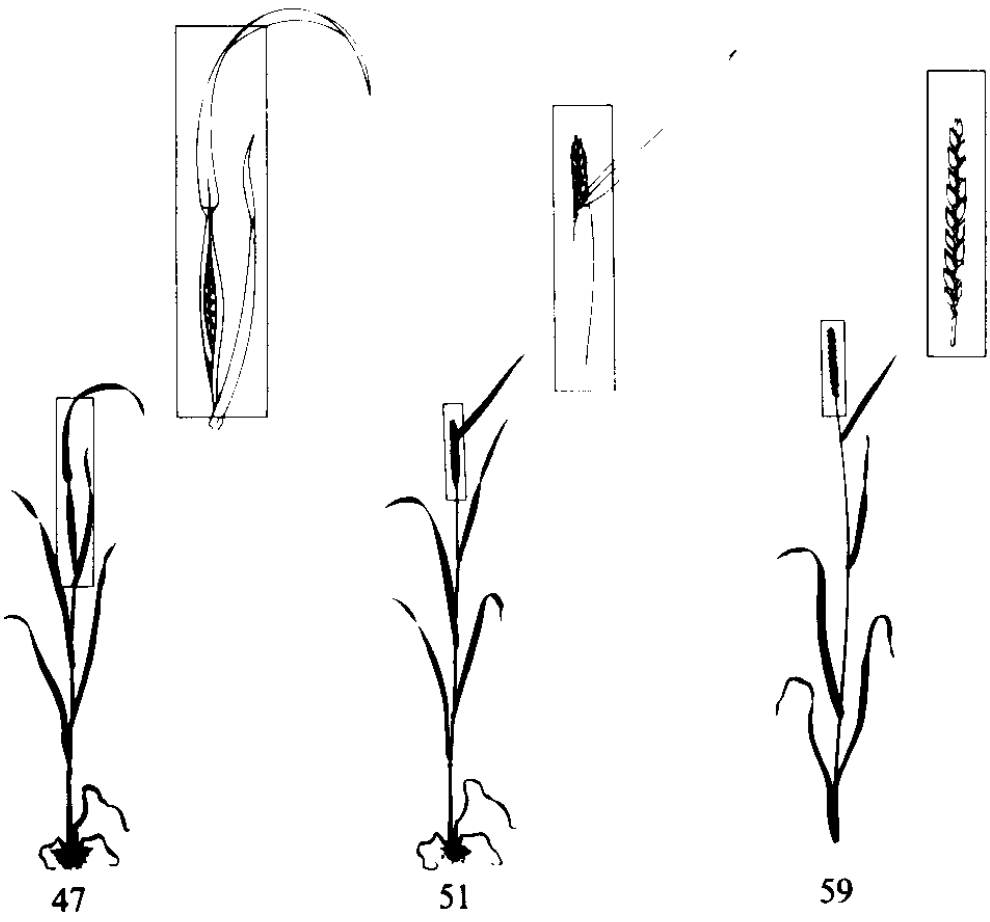
Phenological growth stages and BBCH-identification keys of cereals

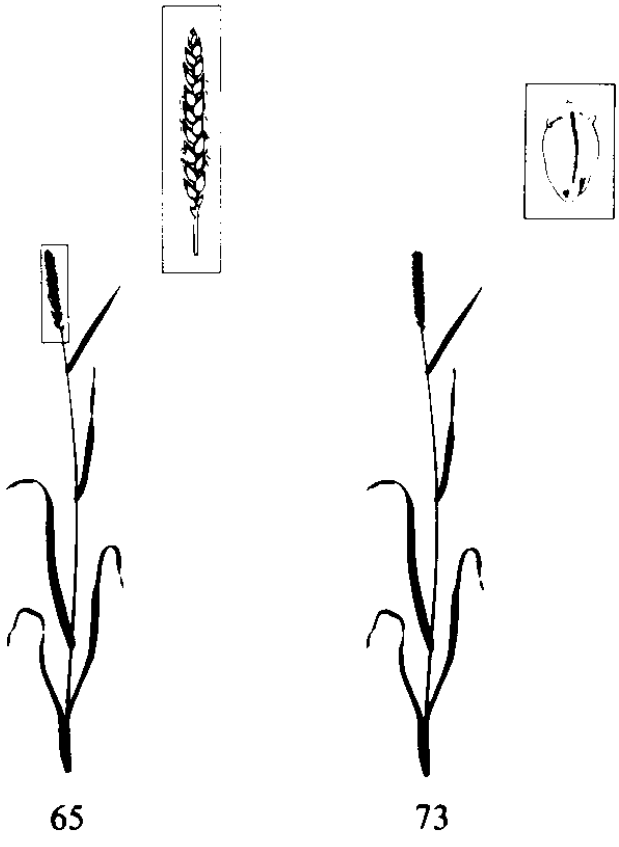
Code	Description
	Principal growth stage 8: Ripening
83	Early dough
85	Soft dough: grain content soft but dry. Fingernail impression not held
87	Hard dough: grain content solid. Fingernail impression held
89	Fully ripe: grain hard, difficult to divide with thumbnail
	Principal growth stage 9: Senescence
92	Over-ripe: grain very hard, cannot be dented by thumbnail
93	Grains loosening in day-time
97	Plant dead and collapsing
99	Harvested product

Cereals



Cereals





Rice Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of rice (*Oryza sativa* L.)

Code	Description
Principal growth stage 0: Germination	
00	Dry seed (caryopsis)
01	Beginning of seed imbibition
03	Seed imbibition complete (pigeon breast)
05	Radicle emerged from caryopsis
06	Radicle elongated, root hairs and/or side roots visible
07	Coleoptile emerged from caryopsis (in water-rice this stage occurs before stage 05)
09	Imperfect leaf emerges (still rolled) at the tip of the coleoptile
Principal growth stage 1: Leaf development[1, 2]	
10	Imperfect leaf unrolled, tip of first true leaf visible
11	First leaf unfolded
12	2 leaves unfolded
13	3 leaves unfolded
1 .	Stages continuous till . . .
19	9 or more leaves unfolded
Principal growth stage 2: Tillering[3]	
21	Beginning of tillering: first tiller detectable
22	2 tillers detectable
23	3 tillers detectable
2 .	Stages continuous till ...
29	Maximum number of tillers detectable
Principal growth stage 3: Stem elongation	
30	Panicle initiation or green ring stage: chlorophyll accumulates in the stem tissue, forming a green ring
32	Panicle formation: panicle 1–2 mm in length
34	Internode elongation or jointing stage: internodes begin to elongate, panicle more than 2 mm long (variety-dependent)
37	Flag leaf just visible, still rolled, panicle moving upwards
39	Flag leaf stage: flag leaf unfolded, collar regions (auricle and ligule) of flag leaf and penultimate leaf aligned (pre-boot stage)

[1] A leaf is unfolded when its ligule is visible or the tip of the next leaf is visible

[2] Tillering or stem elongation may occur earlier than stage 13; in this case continue with stages 21 or 30

[3] If stem elongation begins before the end of tillering continue with stage 30

Rice Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of rice

Code	Description
Principal growth stage 4: Booting	
41	Early boot stage: upper part of stem slightly thickened, sheath of flag leaf about 5 cm out of penultimate leaf sheath
43	Mid boot stage: sheath of flag leaf 5–10 cm out of the penultimate leaf sheath
45	Late boot stage: flag leaf sheath swollen, sheath of flag leaf more than 10 cm out of penultimate leaf sheath
47	Flag leaf sheath opening
49	Flag leaf sheath open
Principal growth stage 5: Inflorescence emergence, heading[4]	
51	Beginning of panicle emergence: tip of inflorescence emerged from sheath
52	20% of panicle emerged
53	30% of panicle emerged
54	40% of panicle emerged
55	Middle of panicle emergence: neck node still in sheath
56	60% of panicle emerged
57	70% of panicle emerged
58	80% of panicle emerged
59	End of panicle emergence: neck node level with the flag leaf auricle, anthers not yet visible
Principal growth stage 6: Flowering, anthesis	
61	Beginning of flowering: anthers visible at top of panicle
65	Full flowering: anthers visible on most spikelets
69	End of flowering: all spikelets have completed flowering but some dehydrated anthers may remain
Principal growth stage 7: Development of fruit	
71	Watery ripe: first grains have reached half their final size
73	Early milk
75	Medium milk: grain content milky
77	Late milk
Principal growth stage 8: Ripening	
83	Early dough
85	Soft dough: grain content soft but dry, fingernail impression not held, grains and glumes still green
87	Hard dough: grain content solid, fingernail impression held
89	Fully ripe: grain hard, difficult to divide with thumbnail

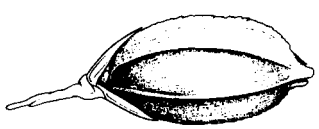
[4] Flowering usually starts before stage 55; continue with principal stage 6

Rice Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of rice

Code	Description
Principal growth stage 9: Senescence	
92	Over-ripe: grain very hard, cannot be dented by thumbnail
97	Plant dead and collapsing
99	Harvested product

Rice



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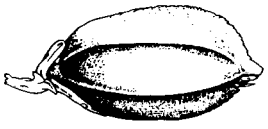

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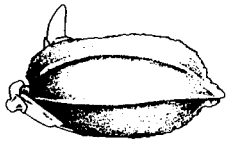

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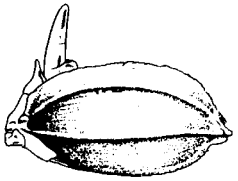
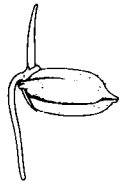


05

13

21



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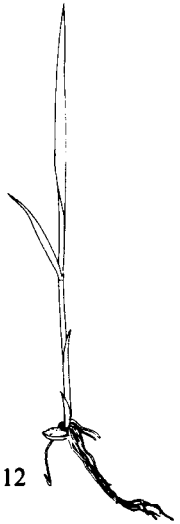

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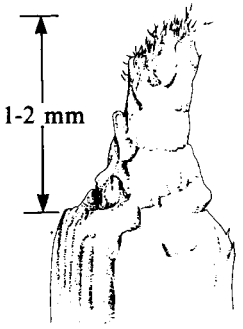
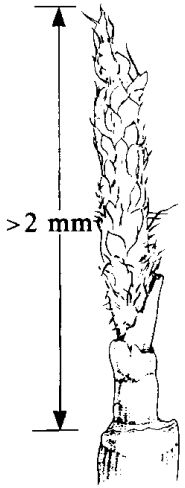
32

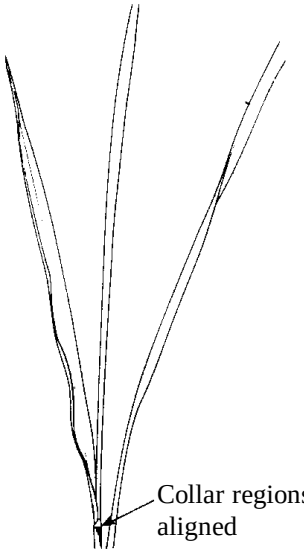


32 Detail

Rice



34 Detail



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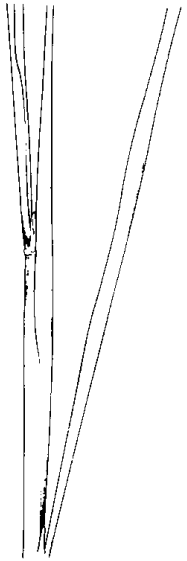

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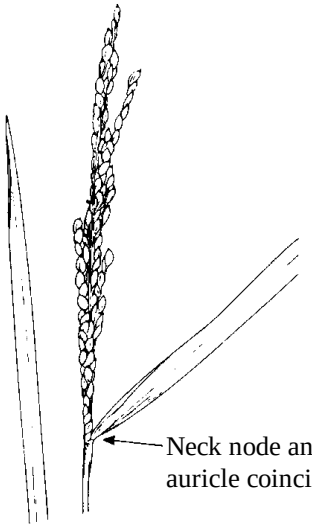

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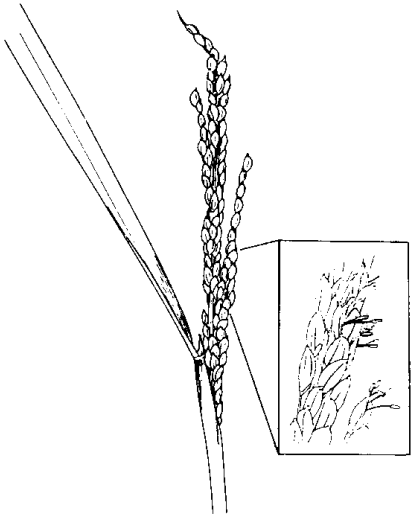

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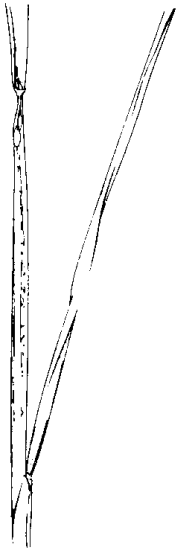

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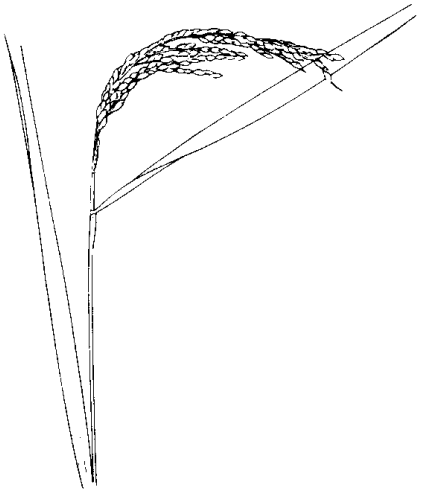


71–92 (Ripening)

Maize Weber and Bleiholder, 1990; Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of maize
(*Zea mays* L.)

Code	Description
Principal growth stage 0: Germination	
00	Dry seed (caryopsis)
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from caryopsis
06	Radicle elongated, root hairs and/or side roots visible
07	Coleptile emerged from caryopsis
09	Emergence: coleoptile penetrates soil surface (cracking stage)
Principal growth stage 1: Leaf development[1, 2]	
10	First leaf through coleoptile
11	First leaf unfolded
12	2 leaves unfolded
13	3 leaves unfolded
1 .	Stages continuous till . . .
19	9 or more leaves unfolded
Principal growth stage 3: Stem elongation	
30	Beginning of stem elongation
31	First node detectable
32	2 nodes detectable
33	3 nodes detectable
3 .	Stages continuous till . . .
39	9 or more nodes detectable[3]
Principal growth stage 5: Inflorescence emergence, heading	
51	Beginning of tassel emergence: tassel detectable at top of stem
53	Tip of tassel visible
55	Middle of tassel emergence: middle of tassel begins to separate
59	End of tassel emergence: tassel fully emerged and separated

[1] A leaf may be described as unfolded when its ligule is visible or the tip of next leaf is visible

[2] Tillering or stem elongation may occur earlier than stage 19; in this case continue with principal growth stage 3

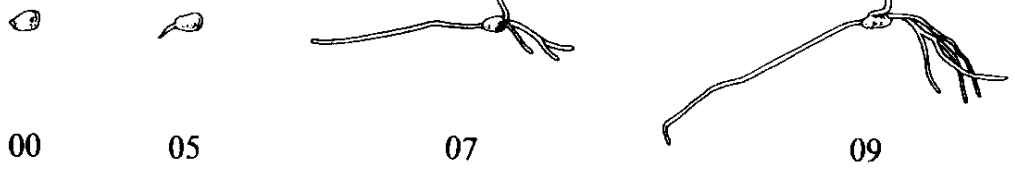
[3] In maize, tassel emergence may occur earlier, in this case continue with principal growth stage 5

Maize Weber and Bleiholder, 1990; Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of maize

Code	Description
Principal growth stage 6: Flowering, anthesis	
61	Male: stamens in middle of tassel visible Female: tip of ear emerging from leaf sheath
63	Male: beginning of pollen shedding Female: tips of stigmata visible
65	Male: upper and lower parts of tassel in flower Female: stigmata fully emerged
67	Male: flowering completed Female: stigmata drying
69	End of flowering: stigmata completely dry
Principal growth stage 7: Development of fruit	
71	Beginning of grain development: kernels at blister stage, about 16% dry matter
73	Early milk
75	Kernels in middle of cob yellowish-white (variety-dependent), content milky, about 40% dry matter
79	Nearly all kernels have reached final size
Principal growth stage 8: Ripening	
83	Early dough: kernel content soft, about 45% dry matter
85	Dough stage: kernels yellowish to yellow (variety dependent), about 55% dry matter
87	Physiological maturity: black dot/layer visible at base of kernels, about 60% dry matter
89	Fully ripe: kernels hard and shiny, about 65% dry matter
Principal growth stage 9: Senescence	
97	Plant dead and collapsing
99	Harvested product

Maize



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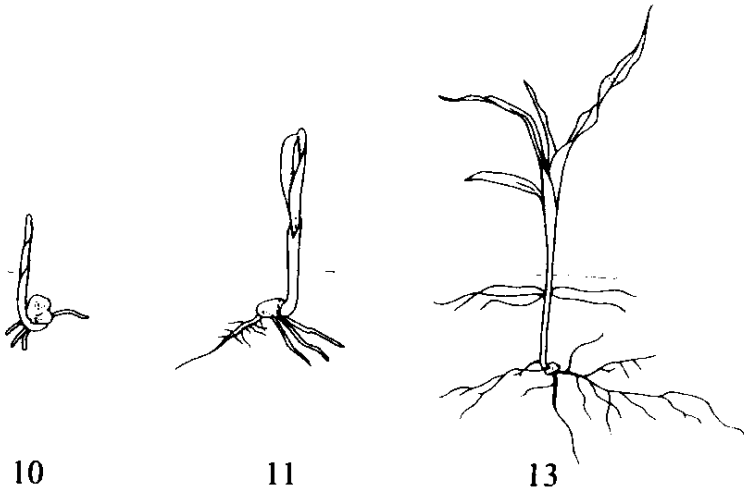

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Maize

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Oilseed rape Weber and Bleiholder, 1990; Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of oilseed rape
(*Brassica napus* L. ssp. *napus*)

Code	Description
Principal growth stage 0: Germination	
00	Dry seed
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from seed
07	Hypocotyl with cotyledons emerged from seed
08	Hypocotyl with cotyledons growing towards soil surface
09	Emergence: cotyledons emerge through soil surface
Principal growth stage 1: Leaf development[1]	
10	Cotyledons completely unfolded
11	First leaf unfolded
12	2 leaves unfolded
13	3 leaves unfolded
1 .	Stages continuous till . . .
19	9 or more leaves unfolded
Principal growth stage 2: Formation of side shoots	
20	No side shoots
21	Beginning of side shoot development: first side shoot detectable
22	2 side shoots detectable
23	3 side shoots detectable
2 .	Stages continuous till . . .
29	End of side shoot development: 9 or more side shoots detectable
Principal growth stage 3: Stem elongation[2]	
30	Beginning of stem elongation: no internodes (“rosette”)
31	1 visibly extended internode
32	2 visibly extended internodes
33	3 visibly extended internodes
3 .	Stages continuous till . . .
39	9 or more visibly extended internodes

[1] Stem elongation may occur earlier than stage stage 19; in this case continue with stage 20

[2] Visibly extended internode n develops between leaf n and leaf n+1

Oilseed rape Weber and Bleiholder, 1990; Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of oilseed rape

Code	Description
Principal growth stage 5: Inflorescence emergence	
50	Flower buds present, still enclosed by leaves
51	Flower buds visible from above (“green bud”)
52	Flower buds free, level with the youngest leaves
53	Flower buds raised above the youngest leaves
55	Individual flower buds (main inflorescence) visible but still closed
57	Individual flower buds (secondary inflorescences) visible but still closed
59	First petals visible, flower buds still closed (“yellow bud”)
Principal growth stage 6: Flowering	
60	First flowers open
61	10% of flowers on main raceme open, main raceme elongating
62	20% of flowers on main raceme open
63	30% of flowers on main raceme open
64	40% of flowers on main raceme open
65	Full flowering: 50% flowers on main raceme open, older petals falling
67	Flowering declining: majority of petals fallen
69	End of flowering
Principal growth stage 7: Development of fruit	
71	10% of pods have reached final size
72	20% of pods have reached final size
73	30% of pods have reached final size
74	40% of pods have reached final size
75	50% of pods have reached final size
76	60% of pods have reached final size
77	70% of pods have reached final size
78	80% of pods have reached final size
79	Nearly all pods have reached final size

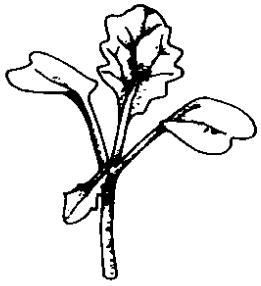
Oilseed rape Weber and Bleiholder, 1990; Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of oilseed rape

Code	Description
Principal growth stage 8: Ripening	
80	Beginning of ripening: seed green, filling pod cavity
81	10% of pods ripe, seeds dark and hard
82	20% of pods ripe, seeds dark and hard
83	30% of pods ripe, seeds dark and hard
84	40% of pods ripe, seeds dark and hard
85	50% of pods ripe, seeds dark and hard
86	60% of pods ripe, seeds dark and hard
87	70% of pods ripe, seeds dark and hard
88	80% of pods ripe, seeds dark and hard
89	Fully ripe: nearly all pods ripe, seeds dark and hard
Principal growth stage 9: Senescence	
97	Plant dead and dry
99	Harvested product

Oilseed rape

10



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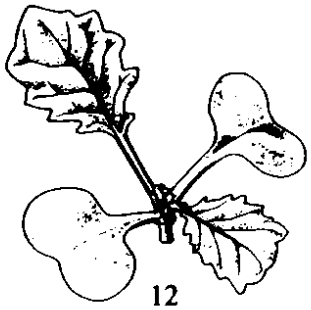

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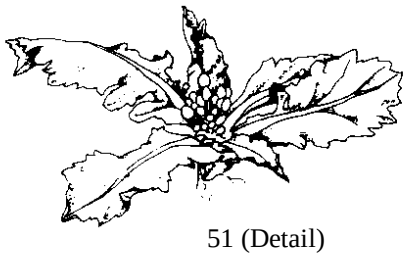
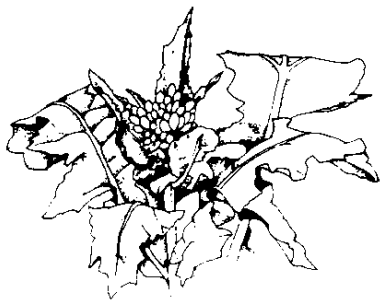


51 (Detail)

51

Oilseed rape



53 (Detail)

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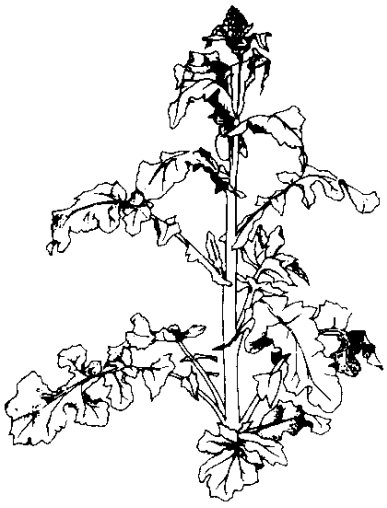

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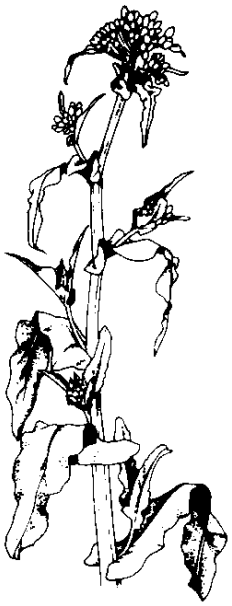

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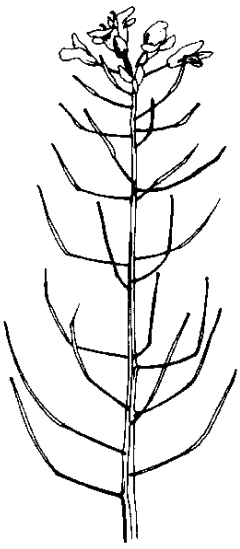

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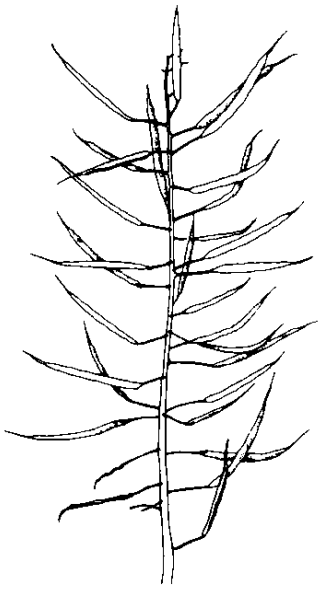

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Faba bean Weber and Bleiholder, 1990; Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of faba bean
(*Vicia faba* L.)

Code	Description
Principal growth stage 0: Germination	
00	Dry seed
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from seed
07	Shoot emerged from seed (plumule apparent)
08	Shoot growing towards soil surface
09	Emergence: shoot emerges through soil surface
Principal growth stage 1: Leaf development[1]	
10	Pair of scale leaves visible (may be eaten or lost)
11	First leaf unfolded
12	2 leaves unfolded
13	3 leaves unfolded
1 .	Stages continuous till . . .
19	9 or more leaves unfolded
Principal growth stage 2: Formation of side shoots	
20	No side shoots
21	Beginning of side shoot development: first side shoot detectable
22	2 side shoots detectable
23	3 side shoots detectable
2 .	Stages continuous till . . .
29	End of side shoot development: 9 or more side shoots detectable
Principal growth stage 3: Stem elongation	
30	Beginning of stem elongation
31	One visibly extended internode[2]
32	2 visibly extended internodes
33	3 visibly extended internodes
3 .	Stages continuous till . . .
39	9 or more visibly extended internodes

[1] Stem elongation may occur earlier than stage 19; in this case continue with the principal stage 3
[2] First internode extends from the scale leaf node to the first true leaf node

Faba bean Weber and Bleiholder, 1990; Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of faba bean

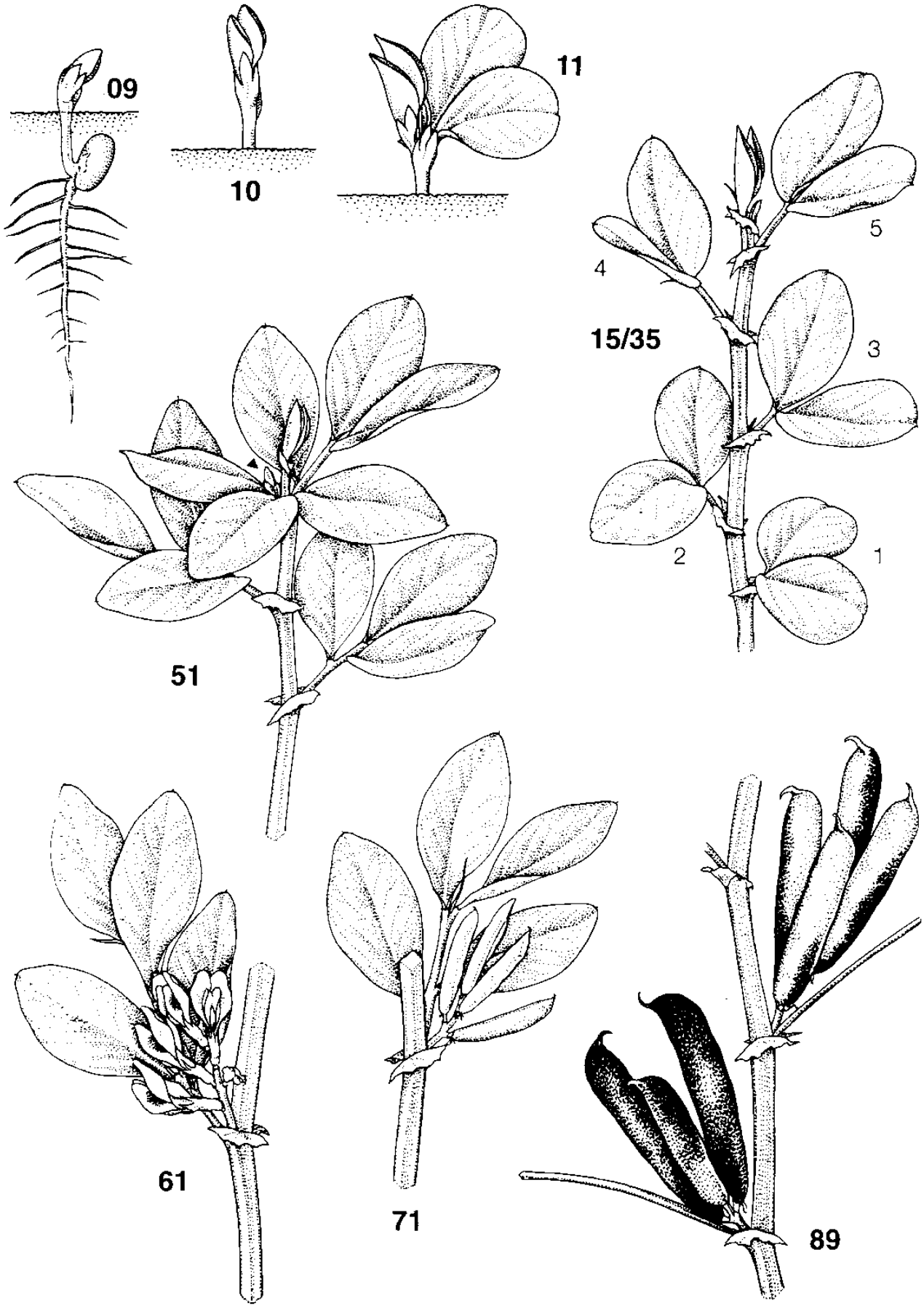
Code	Description
Principal growth stage 5: Inflorescence emergence	
50	Flower buds present, still enclosed by leaves
51	First flower buds visible outside leaves
55	First individual flower buds visible outside leaves but still closed
59	First petals visible, many individual flower buds, still closed
Principal growth stage 6: Flowering	
60	First flowers open
61	Flowers open on first raceme
63	Flowers open 3 racemes per plant
65	Full flowering: flowers open on 5 racemes per plant
67	Flowering declining
69	End of flowering
Principal growth stage 7: Development of fruit	
70	First pods have reached final length (“flat pod”)
71	10% of pods have reached final length
72	20% of pods have reached final length
73	30% of pods have reached final length
74	40% of pods have reached final length
75	50% of pods have reached final length
76	60% of pods have reached final length
77	70% of pods have reached final length
78	80% of pods have reached final length
79	Nearly all pods have reached final length
Principal growth stage 8: Ripening	
80	Beginning of ripening: seed green, filling pod cavity
81	10% of pods ripe, seeds dry and hard
82	20% of pods ripe, seeds dry and hard
83	30% of pods ripe and dark, seeds dry and hard
84	40% of pods ripe and dark, seeds dry and hard
85	50% of pods ripe and dark, seeds dry and hard
86	60% of pods ripe and dark, seeds dry and hard
87	70% of pods ripe and dark, seeds dry and hard
88	80% of pods ripe and dark, seeds dry and hard
89	Fully ripe: nearly all pods dark, seeds dry and hard

Faba bean Weber and Bleiholder, 1990; Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of faba bean

Code	Description
Principal growth stage 9: Senescence	
93	Stems begin to darken
95	50% of stems brown or black
97	Plant dead and dry
99	Harvested product

Faba bean



Sunflower Weber and Bleiholder, 1990; Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of sunflower
(*Helianthus annuus* L.)

Code	Description
Principal growth stage 0: Germination	
00	Dry seed (achene)
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from seed
06	Radicle elongated, root hairs developing
07	Hypocotyl with cotyledons emerged from seed
08	Hypocotyl with cotyledons growing towards soil surface
09	Emergence: cotyledons emerge through soil surface
Principal growth stage 1: Leaf development[1]	
10	Cotyledons completely unfolded
12	2 leaves (first pair) unfolded
14	4 leaves (second pair) unfolded
15	5 leaves unfolded
16	6 leaves unfolded
17	7 leaves unfolded
18	8 leaves unfolded
19	9 or more leaves unfolded
Principal growth stage 3: Stem elongation	
30	Beginning of stem elongation
31	1 visibly extended internode
32	2 visibly extended internodes
33	3 visibly extended internodes
3 .	Stages continuous till . . .
39	9 or more visibly extended internodes
Principal growth stage 5: Inflorescence emergence	
51	Inflorescence just visible between youngest leaves
53	Inflorescence separating from youngest leaves, bracts distinguishable from foliage leaves
55	Inflorescence separated from youngest foliage leaf
57	Inflorescence clearly separated from foliage leaves
59	Ray florets visible between the bracts; inflorescence still closed

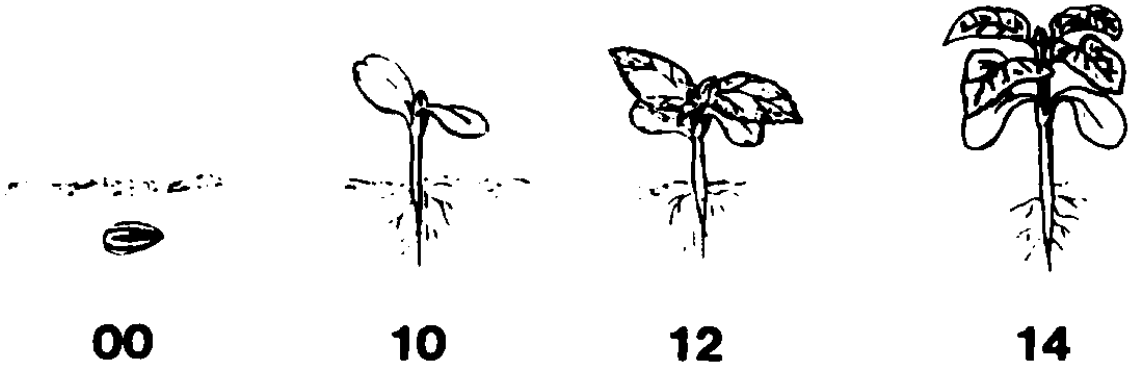
[1] Stem elongation may occur earlier than stage 19; in this case continue with the principal stage 3

Sunflower Weber and Bleiholder, 1990; Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of sunflower

Code	Description
Principal growth stage 6: Flowering	
61	Beginning of flowering: ray florets extended, disc florets visible in outer third of inflorescence
63	Disc florets in outer third of inflorescence in bloom (stamens and stigmata visible)
65	Full flowering: disc florets in middle third of inflorescence in bloom (stames and stigmata visible)
67	Flowering declining: disc florets in inner third of inflorescence in bloom (stames and stigmata visible)
69	End of flowering: most disc florets have finished flowering, ray florets dry or fallen
Principal growth stage 7: Development of fruit	
71	Seeds on outer edge of the inflorescence are grey and have reached final size
73	Seeds on outer third of the inflorescence are grey and have reached final size
75	Seeds on middle third of the inflorescence are grey and have reached final size
79	Seeds on inner third of the inflorescence are grey and have reached final size
Principal growth stage 8: Ripening	
80	Beginning of ripening: seeds on outer third of anthocarp black and hard. Back of anthocarp still green
81	Seeds on outer third of anthocarp dark and hard. Back ofanthocarp still green
83	Dark of anthocarp yellowish-green, bracts still green. Seeds about 50% dry matter
85	Seeds on middle third of anthocarp dark and hard. Back of anthocarp yellow, bracts brown edged. Seeds about 60% dry matter
87	Physiological ripeness: back of the anthocarp yellow. Bracts marbled brown. Seeds about 75–80% dry matter
89	Fully ripe: seeds on inner third of anthocarp dark and hard. Back of anthocarp brown. Bracts brown. Seeds about 85% dry matter
Principal growth stage 9:	
92	Over ripe, seeds over 90% dry matter
97	Plant dead and dry
99	Harvested product

Sunflower



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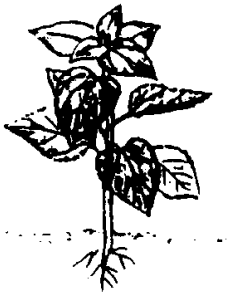
Sunflower



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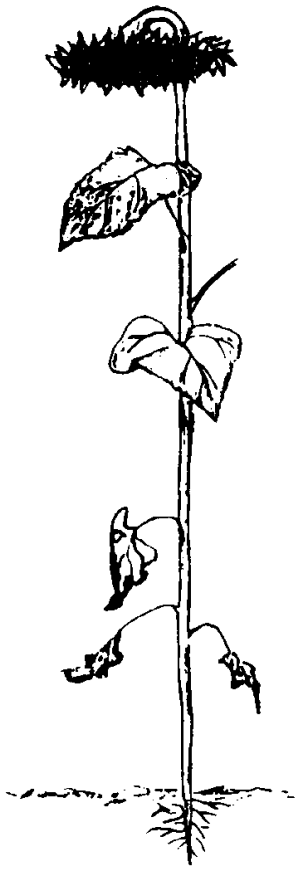

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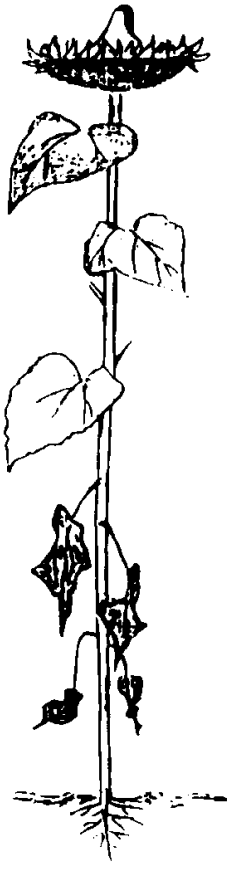

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Beet Meier et al., 1993

Phenological growth stages and BBCH-identification keys of beet
(*Beta vulgaris* L. ssp. *vulgaris*)

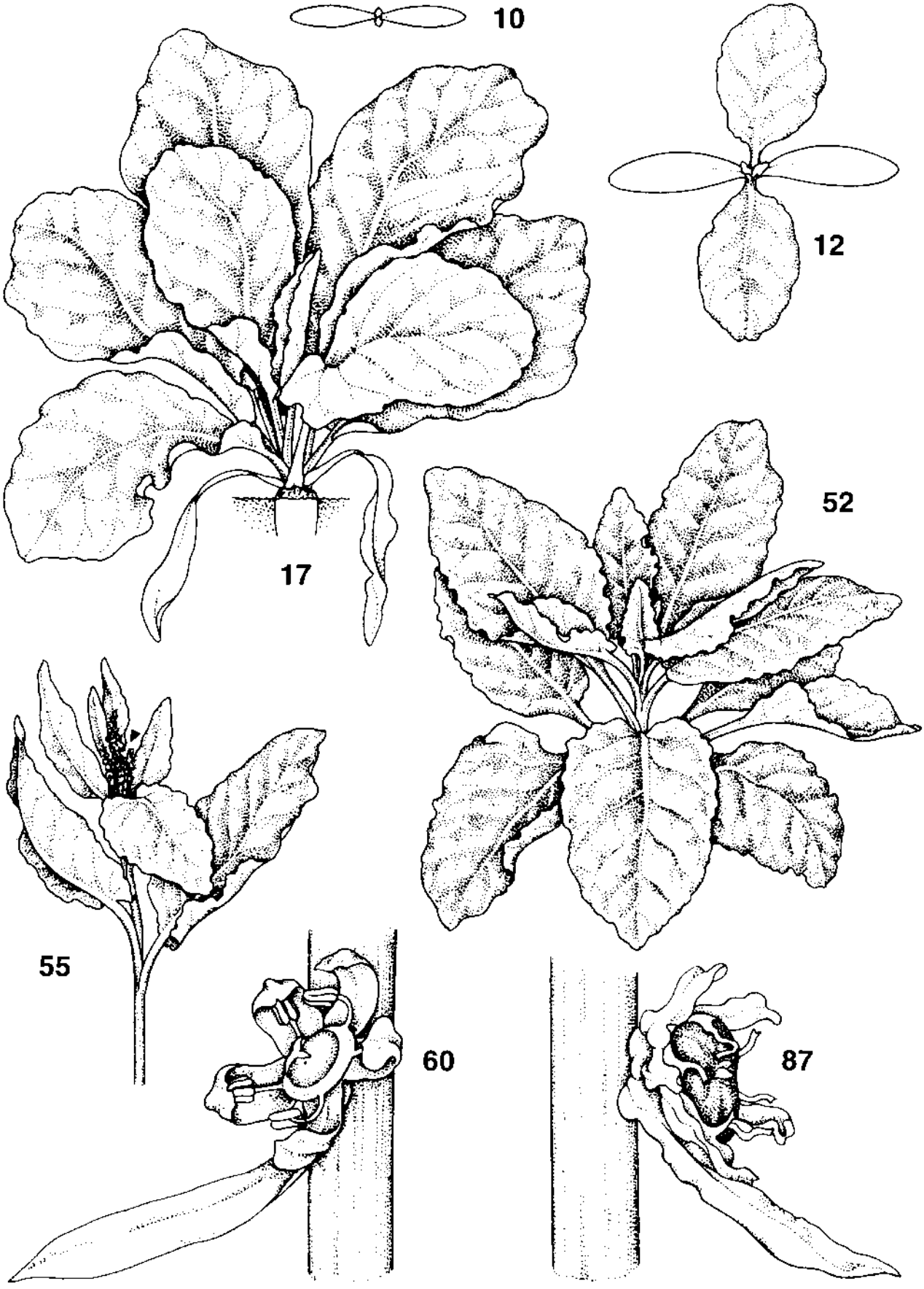
Code	Description
	Principal growth stage 0: Germination
00	Dry seed
01	Beginning of imbibition: seeds begins to take up water
03	Seed imbibition complete (pellet cracked)
05	Radicle emerged from seed (pellet)
07	Shoot emerged from seed (pellet)
09	Emergence: shoot emerges through soil surface
	Principal growth stage 1: Leaf development (youth stage)
10	First leaf visible (pinhead-size): cotyledons horizontally unfolded
11	First pair of leaves visible, not yet unfolded (pea-size)
12	2 leaves (first pair of leaves) unfolded
14	4 leaves (2nd pair of leaves) unfolded
15	5 leaves unfolded
1 .	Stages continuous till . . .
19	9 and more leaves unfolded
	Principal growth stage 3: Rosette growth (crop cover)
31	Beginning of crop cover: leaves cover 10% of ground
32	Leaves cover 20% of ground
33	Leaves cover 30% of ground
34	Leaves cover 40% of ground
35	Leaves cover 50% of ground
36	Leaves cover 60% of ground
37	Leaves cover 70% of ground
38	Leaves cover 80% of ground
39	Crop cover complete: leaves cover 90% of ground
	Principal growth stage 4: Development of harvestable vegetative plant parts Beet root
49	Beet root has reached harvestable size
	Principal growth stage 5: Inflorescence emergence (2nd year of growth)
51	Beginning of elongation of main stem
52	Main stem 20 cm long
53	Side shoot buds visible on main stem
54	Side shoots clearly visible on main stem
55	First individual flower buds on side shoots visible
59	First bracts visible; flower buds still closed

Beet Meier et al., 1993

Phenological growth stages and BBCH-identification keys of beet

Code	Description
Principal growth stage 6: Flowering	
60	First flowers open
61	Beginning of flowering: 10% of flowers open
62	20% of flowers open
63	30% of flowers open
64	40% of flowers open
65	Full flowering: 50% of flowers open
67	Flowering declining: 70% of flowers open or dry
69	End of flowering: all flowers dry, fruit set visible
Principal growth stage 7: Development of fruit	
71	Beginning of seed development: seeds visible in infructescence
75	Pericarp green; fruit still mouldable; perisperm milky; colour of seed coat: beige
Principal growth stage 8: Ripening	
81	Beginning of ripening: pericarp green-brown, seed coat light brown
85	Pericarp light brown, seed coat reddish brown
87	Pericarp hard, seed coat dark brown
89	Fully ripe: seed coat final colour (specific to variety and species), perisperm hard
Principal growth stage 9: Senescence	
91	Beginning of leaf discolouration
93	Most leaves yellowish
95	50% of leaves brownish
97	Leaves dead
99	Harvested product (seeds)

Beet



Potato Hack et al., 1993

Phenological growth stages and BBCH-identification keys of potato
(*Solanum tuberosum* L.)

Code		Description of development from tuber	Description of development from seed
2- and 3digit			
Principal growth stage 0: Sprouting/Germination			
00	000	Innate or enforced dormancy, tuber not sprouted	Dry seed
01	001	Beginning of sprouting: sprouts visible (< 1 mm)	Beginning of seed imbibition
02	002	Sprouts upright (< 2 mm)	
03	003	End of dormancy: sprouts 2–3 mm	Seed imbibition complete
05	005	Beginning of root formation	Radicle (root) emerged from seed
07	007	Beginning of stem formation	Hypocotyl with cotyledons breaking
08	008	Stems growing towards soil surface, formation of scale leaves in the axils of which stolons will develop later	Hypocotyl with cotyledons growing towards soil surface
09	009	Emergence: stems break through soil surface	Emergence: cotyledons break through soil surface
	021–029[1]		

[1] For second generation sprouts

Potato Hack et al., 1993

Phenological growth stages and BBCH-identification keys of potato

Code		Description of development from tuber and seed
2- and 3digit		
Principal growth stage 1: Leaf development		
10	100	From tuber: first leaves begin to extend From seed: cotyledons completely unfolded
11	101	1st leaf of main stem unfolded (> 4 cm)
12	102	2nd leaf of main stem unfolded (> 4 cm)
13	103	3rd leaf Auf main stem unfolded (> 4 cm)
1 .	10 .	Stages continuous till . . .
19	109	9 or more leaves of main stem unfolded (> 4cm) (2digit);[2] 9 leaves of main stem unfolded (> 4 cm) (3digit)
	110	10th leaf of main stem unfolded (> 4 cm)
	11 .	Stages continuous till . . .
	119	19. leaf of main stem unfolded (> 4 cm)
	121	First leaf of 2nd order branch above first inflorescence unfolded (> 4 cm)
	122	2nd leaf of 2nd order branch above first inflorescence unfolded (> 4 cm)
	12 .	Stages continuous till . . .
	131	First leaf of 3rd order branch above 2nd inflorescence unfolded (> 4 cm)
	132	2nd leaf of 3rd order branch above 2nd inflorescence unfolded (> 4 cm)
	13 .	Stages continuous till . . .
	1NX	Xth leaf of nth order branch above n-1th inflorescence unfolded (> 4 cm)

[2] Stem development stops after termination of main stem by an inflorescence. Branches arise from axils of upper leaves of the main stem, exhibiting a sympodial branching pattern

Potato Hack et al., 1993

Phenological growth stages and BBCH-identification keys of potato

Codes		Description
2- and 3digit		
Principal growth stage 2: Formation of basal side shoots below and above soil surface (main stem)		
21	201	First basal side shoot visible (> 5 cm)
22	202	2nd basal side shoot visible (> 5 cm)
23	203	3rd basal side shoot visible (> 5 cm)
2 .	20 .	Stages continuous till . . .
29	209	9 or more basal side shoots visible (> 5 cm)
2- and 3digit		
Principal growth stage 3: Main stem elongation (crop cover)		
31	301	Beginning of crop cover: 10% of plants meet between rows
32	302	20% off plants meet between rows
33	303	30% of plants meet between rows
34	304	40% of plants meet between rows
35	305	50% of plants meet between rows
36	306	60% of plants meet between rows
37	307	70% of plants meet between rows
38	308	80% of plants meet between rows
39	309	Crop cover complete: about 90% of plants meet between rows
2- and 3digit		
Principal growth stage 4: Tuber formation		
40	400	Tuber initiation: swelling of first stolon tips to twice the diameter of subtending stolon
41	401	10% of total final tuber mass reached
42	402	20% of total final tuber mass reached
43	403	30% of total final tuber mass reached
44	404	40% of total final tuber mass reached
45	405	50% of total final tuber mass reached
46	406	60% of total final tuber mass reached
47	407	70% of total final tuber mass reached
48	408	Maximum of total tuber mass reached, tubers detach easily from stolons, skin set not yet complete (skin easily removable with thumb)
49	409	Skin set complete: (skin at apical end of tuber not removable with thumb) 95% of tubers in this stage

Potato Hack et al., 1993

Phenological growth stages and BBCH-identification keys of potato

Codes		Description
2- and 3digit		
Principal growth stage 5: Inflorescence (cyme) emergence		
51	501	First individual buds (1–2 mm) of first inflorescence visible (main stem)
55	505	Buds of first inflorescence extended to 5 mm
59	509	First flower petals of first inflorescence visible
2- and 3digit		
Principal growth stage 5: Inflorescence emergence (continuation)		
	521	Individual buds of 2nd inflorescence visible (second order branch)
	525	Buds of 2nd inflorescence extended to 5 mm open (main stem)
	529	First flower petals of 2nd inflorescence visible above sepals
	531	Individuell buds of 3rd inflorescence visible(3rd order branch)
	535	Buds of 3rd inflorescence extended to 5 mm
	539	First flower petals of 3rd inflorescence visible above sepals
	5N .	Nth inflorescence emerging
2- and 3digit		
Principal growth stage 6: Flowering		
60	600	First open flowers in population
61	601	Beginning of flowering: 10% of flowers in the first inflorescence open (main stem)
62	602	20% of flowers in the first inflorescence open
63	603	30% of flowers in the first inflorescence open
64	604	40% of flowers in the first inflorescence open
65	605	Full flowering: 50% of flowers in the first inflorescence open
66	606	60% of flowers in the first inflorescence open
67	607	70% of flowers in the first inflorescence open
68	608	80% of flowers in the first inflorescence open
69	609	End of flowering in the first inflorescence

Potato Hack et al., 1993

Phenological growth stages and BBCH-identification keys of potato

Codes		Description
2- and 3digit		
Principal growth stage 6: Flowering (continuation)		
	621	Beginning of flowering: 10% of flowers in the 2nd inflorescence open (second order branch)
	625	Full flowering: 50% of flowers in the 2nd inflorescence open
	629	End of flowering in the 2nd inflorescence
	631	Beginning of flowering: 10% of flowers in the 3rd inflorescence open (third order branch)
	635	Full flowering: 50% of flowers in the 3rd inflorescence open
	639	End of flowering in the 3rd inflorescence
	6N .	Nth inflorescence flowering
	6N9	End of flowering
2- and 3digit		
Principal growth stage 7: Development of fruit		
70	700	First berries visible
71	701	10% of berries in the first fructification have reached full size (main stem)
72	702	20% of berries in the first fructification have reached full size
73	703	30% of berries in the first fructification have reached full size
7 .	70 .	Stages continuous till . . .
	721	10% of berries in the 2nd fructification have reached full size (second order branch)
	7N .	Development of berries in nth fructification
	7N9	Nearly all berries in the nth fructification have reached full size (or have been shed)
2- and 3digit		
Principal growth stage 8: Ripening of fruit and seed		
81	801	Berries in the first fructification still green, seed light-coloured (main stem)
85	805	Berries in the first fructification ochre-coloured or brownish
89	809	Berries in the first fructification shrivelled, seed dark
	821	Berries in the 2nd fructification still green, seed light-coloured (second order branch)
	8N .	Ripening of fruit and seed in nth fructification

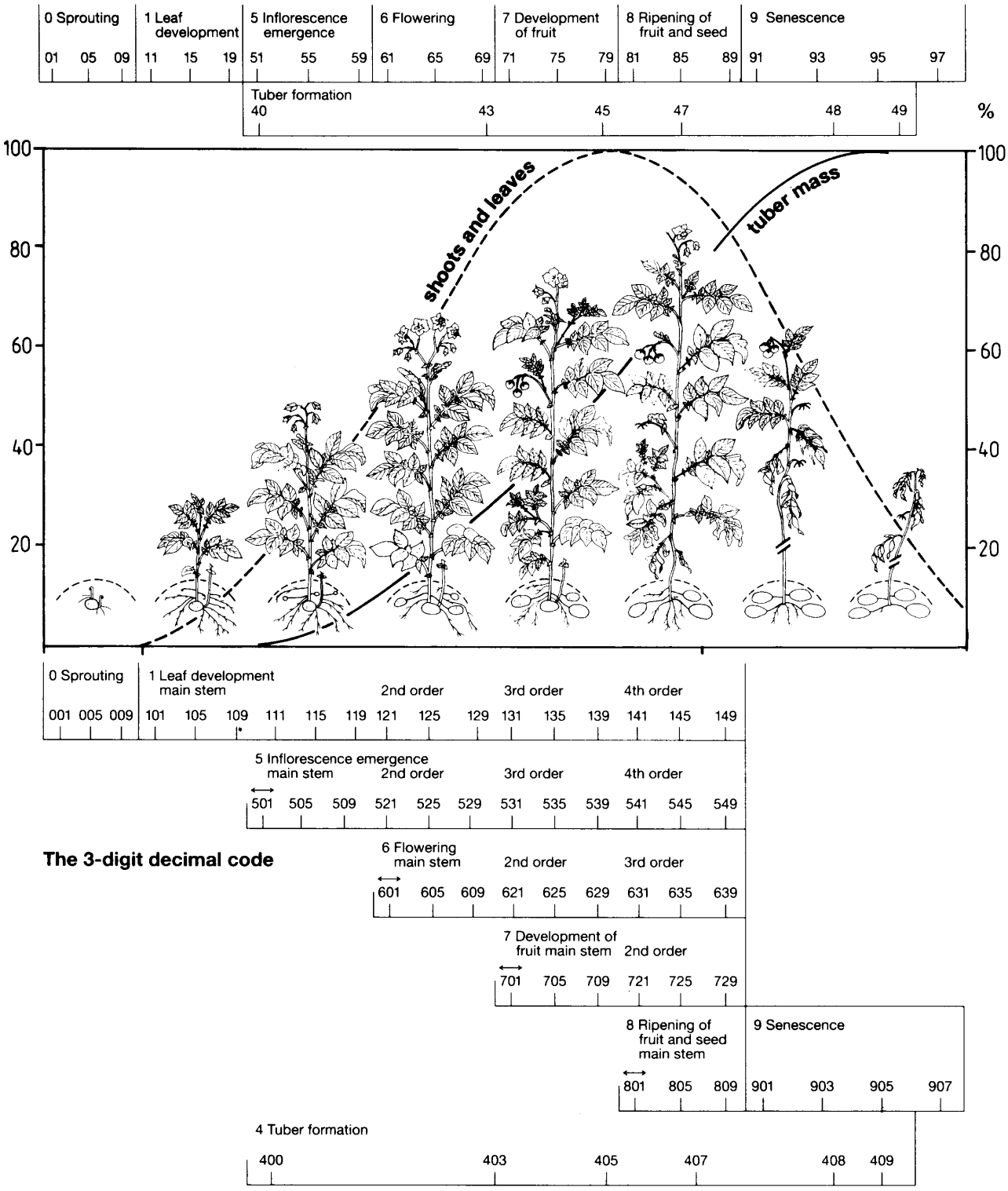
Potato Hack et al., 1993

Phenological growth stages and BBCH-identification keys of potato

Codes		Description
2- and 3digit		
Principal growth stage 9: Senescence		
91	901	Beginning of leaf yellowing
93	903	Most of the leaves yellowish
95	905	50% of the leaves brownish
97	907	Leaves and stem dead, stems bleached and dry
99	909	Harvested product

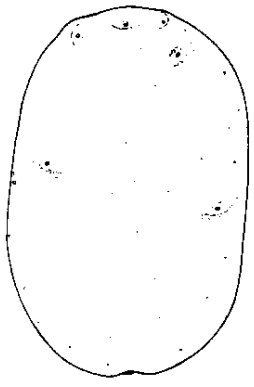
Potato

The 2-digit decimal code



The 3-digit decimal code

Potato



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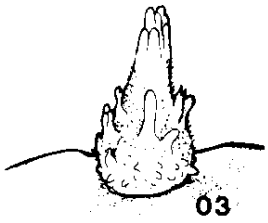

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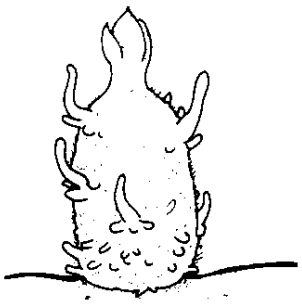

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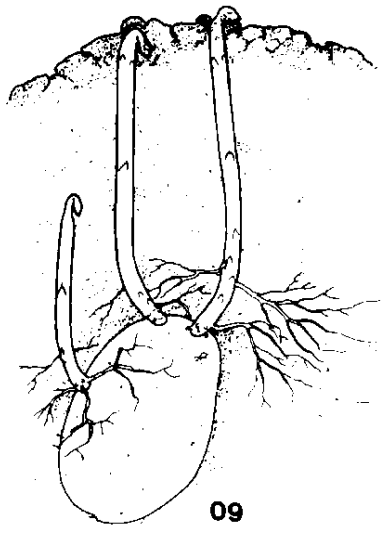

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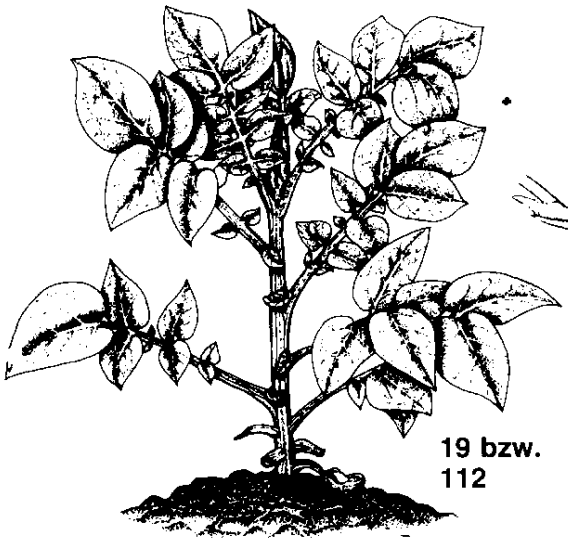

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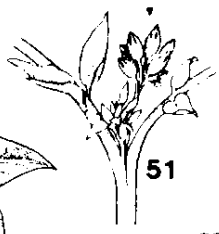

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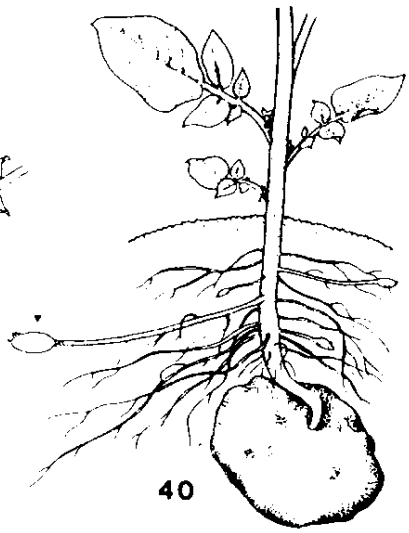

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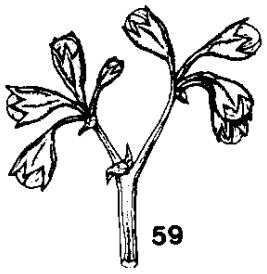

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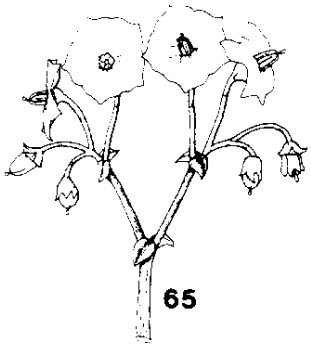

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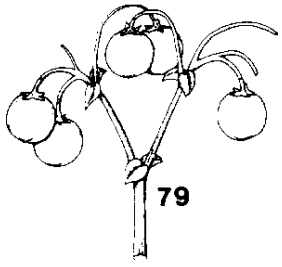

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Pome fruit Meier et al., 1994

Phenological growth stages and identification keys of pome fruit
(apple = *Malus domestica* Borkh., pear = *Pyrus communis* L.)

Code	Description
Principal growth stage 0: Sprouting/Bud development	
00	Dormancy: leaf buds and the thicker inflorescence buds closed and covered by dark brown scales
01	Beginning of leaf bud swelling: buds visibly swollen, bud scales elongated, with light coloured patches
03	End of leaf bud swelling: bud scales light coloured with some parts densely covered by hairs
07	Beginning of bud break: first green leaf tips just visible
09	Green leaf tips about 5 mm above bud scales
Principal growth stage 1: Leaf development	
10	Mouse-ear stage: Green leaf tips 10 mm above the bud scales; first leaves separating
11	First leaves unfolded (others still unfolding)
15	More leaves unfolded, not yet at full size
19	First leaves fully expanded
Principal growth stage 3: Shoot development[1]	
31	Beginning of shoot growth: axes of developing shoots visible
32	Shoots about 20% of final length
33	Shoots about 30% of final length
3 .	Stages continuous till . . .
39	Shoots about 90% of final length
Principal growth stage 5: Inflorescence emergence	
51	Inflorescence buds swelling: bud scales elongated, with light coloured patches
52	End of bud swelling: light coloured bud scales visible with parts densely covered by hairs
53	Bud burst: green leaf tips enclosing flowers visible
54	Mouse-ear stage: green leaf tips 10 mm above bud scales; first leaves separating
55	Flower buds visible (still closed)
56	Green bud stage: single flowers separating (still closed)
57	Pink bud stage: flower petals elongating; sepals slightly open; petals just visible
59	Most flowers with petals forming a hollow ball

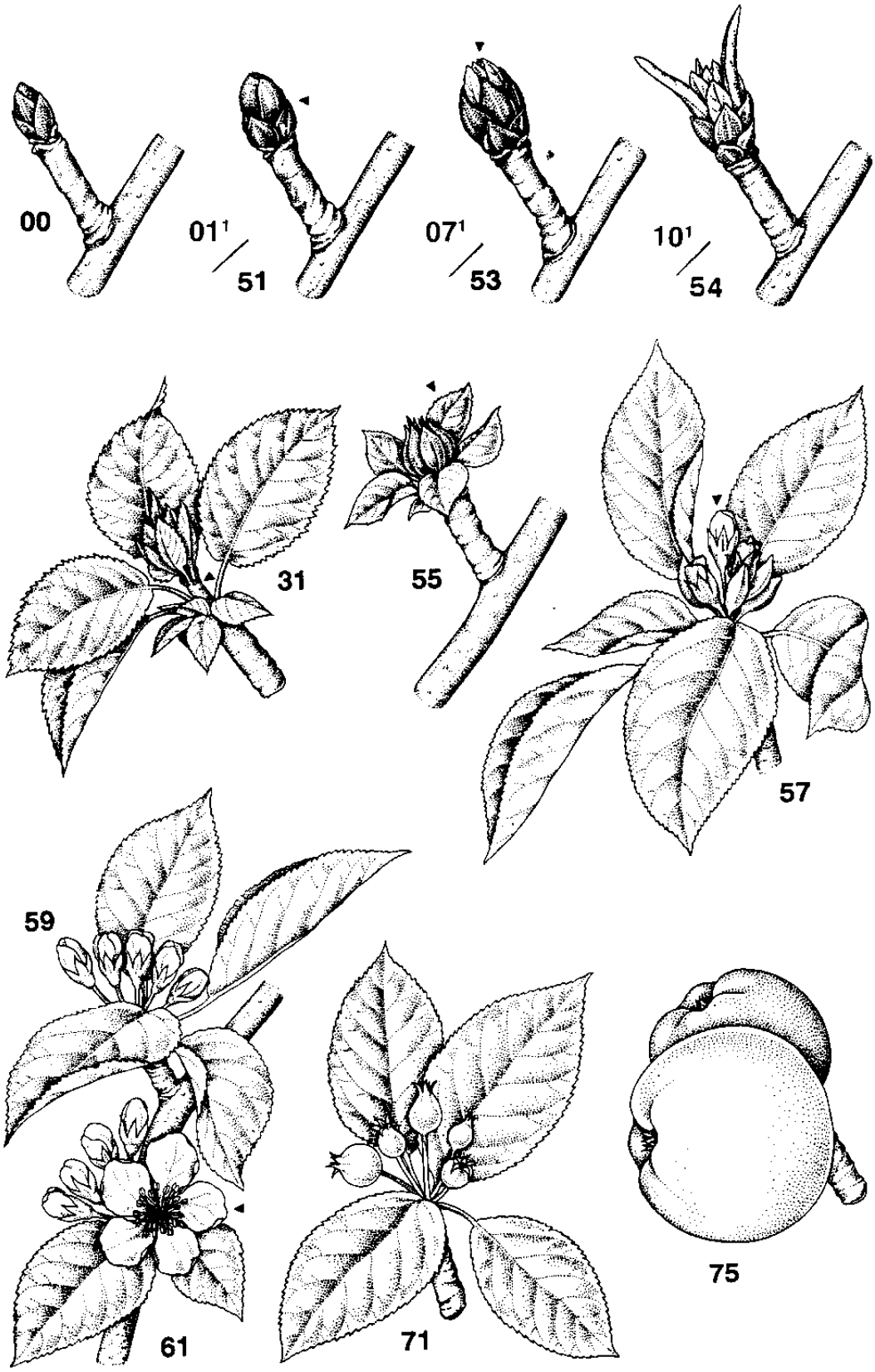
[1] From terminal bud

Pome fruit Meier et al., 1994

Phenological growth stages and identification keys of pome fruit

Code	Description
Principal growth stage 6: Flowering	
60	First flowers open
61	Beginning of flowering: about 10% of flowers open
62	About 20% of flowers open
63	About 30% of flowers open
64	About 40% of flowers open
65	Full flowering: at least 50% of flowers open, first petals falling
67	Flowers fading: majority of petals fallen
69	End of flowering: all petals fallen
Principal growth stage 7: Development of fruit	
71	Fruit size up to 10 mm; fruit fall after flowering
72	Fruit size up to 20 mm
73	Second fruit fall
74	Fruit diameter up to 40 mm; fruit erect (T-stage: underside of fruit and stalk forming a T)
75	Fruit about half final size
76	Fruit about 60% final size
77	Fruit about 70% final size
78	Fruit about 80% final size
79	Fruit about 90% final size
Principal growth stage 8: Maturity of fruit and seed	
81	Beginning of ripening: first appearance of cultivar-specific colour
85	Advanced ripening: increase in intensity of cultivar-specific colour
87	Fruit ripe for picking
89	Fruit ripe for consumption: fruit have typical taste and firmness
Principal growth stage 9: Senescence, beginning of dormancy	
91	Shoot growth completed; terminal bud developed; foliage still fully green
92	Leaves begin to discolour
93	Beginning of leaf fall
95	50% of leaves discoloured
97	All leaves fallen
99	Harvested product

Pome fruit



1 Leave bud smaller and slimer, directly on the long sprout

Stone fruit Meier et al., 1994

Phenological growth stages and BBCH-identification keys of stone fruit
(cherry = *Prunus cerasus* L., plum = *Prunus domestica* L. ssp. *domestica,* peach = *Prunus persica* Batsch., apricot = *Prunus ameriaca* L.)

Code	Description
Principal growth stage 0: Sprouting/Bud development	
00	Dormancy: leaf buds and the thicker inflorescence buds closed and covered by dark brown scales
01	Beginning of bud swelling (leaf buds); light brown scales visible, scales with light coloured edges
03	End of leaf bud swelling: scales separated, light green bud sections visible
09	Green leaf tips visible: brown scales fallen, buds enclosed by light green scales
Principal growth stage 1: Leaf development	
10	First leaves separating: green scales slightly open, leaves emerging
11	First leaves unfolded, axis of developing shoot visible
19	First leaves fully expanded
Principal growth stage 3: Shoot development 1	
31	Beginning of shoot growth: axes of developing shoots visible
32	Shoots about 20% of final length
33	Shoots about 30% of final length
3 .	Stages continuous till . . .
39	Shoots about 90% of final length
Principal growth stage 5: Inflorescence emergence	
51	Inflorescence buds swelling: buds closed, light brown scales visible
53	Bud burst: scales separated, light green bud sections visible
54	Inflorescence enclosed by light green scales, if such scales are formed (not all cultivars)
55	Single flower buds visible (still closed) borne on short stalks, green scales slightly open
56	Flower pedicel elongating; sepals closed; single flowers separating
57	Sepals open: petal tips visible; single flowers with white or pink petals (still closed)
59	Most flowers with petals forming a hollow ball

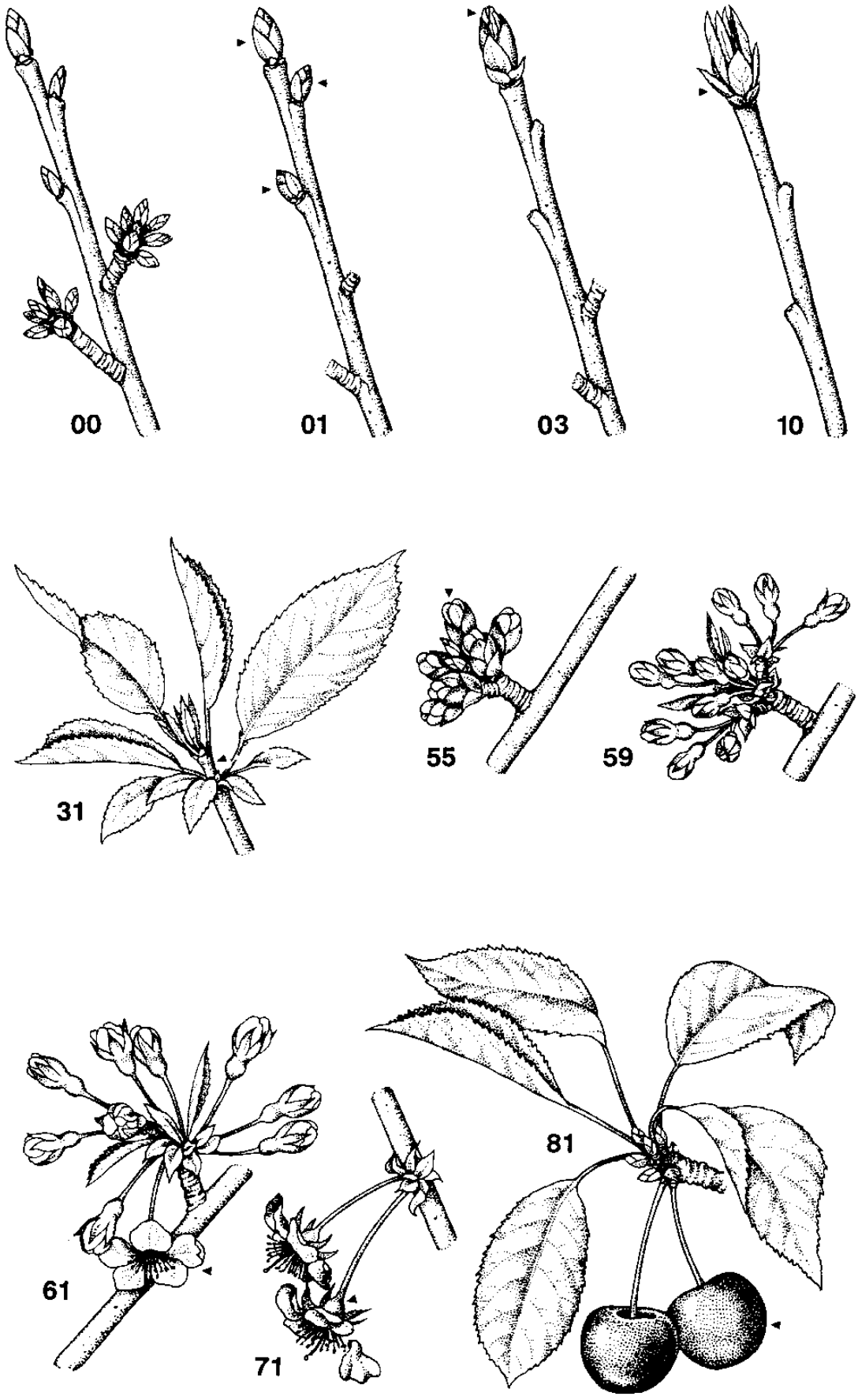
[1] From terminal bud

Stone fruit Meier et al., 1994

Phenological growth stages and BBCH-identification keys of stone fruit

Code	Description
Principal growth stage 6: Flowering	
60	First flowers open
61	Beginning of flowering: about 10% of flowers open
62	About 20% of flowers open
63	About 30% of flowers open
64	About 40% of flowers open
65	Full flowering: at least 50% of flowers open, first petals falling
67	Flowers fading: majority of petals fallen
69	End of flowering: all petals fallen
Principal growth stage 7: Development of fruit	
71	Ovary growing; fruit fall after flowering
72	Green ovary surrounded by dying sepal crown, sepals beginning to fall
73	Second fruit fall
75	Fruit about half final size
76	Fruit about 60% of final size
77	Fruit about 70% of final size
78	Fruit about 80% of final size
79	Fruit about 90% of final size
Principal growth stage 8: Maturity of fruit and seed	
81	Beginning of fruit colouring
85	Colouring advanced
87	Fruit ripe for picking
89	Fruit ripe for consumption: fruit have typical taste and firmness
Principal growth stage 9: Senescence, beginning of dormancy	
91	Shoot growth completed; foliage still fully green
92	Leaves begin to discolour
93	Beginning of leaf fall
95	50% of leaves discoloured or fallen
97	All leaves fallen
99	Harvested product

Stone fruit



Currants Meier et al., 1994

Phenological growth stages and BBCH-identification keys of currants
(black currant = *Ribes nigrum* L., red currant = *Ribes rubrum* L.)

Code	Description
Principal growth stage 0: Sprouting/Bud development	
00	Dormancy: leaf buds and the thicker inflorescence buds closed and covered by dark brown scales
01	Beginning of bud swelling: bud scales elongated
03	End of bud swelling: edges of bud scales light coloured
07	Beginning of bud burst: first green or red leaf tips just visible
09	Leaf tips extended beyond scales
Principal growth stage 1: Leaf development	
10	Leaf tips above the bud scales: first leaves separating
11	First leaves unfolded (others still unfolding)
15	More leaves unfolded, not yet full size
19	First leaves fully expanded

Currants Meier et al., 1994

Phenological growth stages and BBCH-identification keys of currants

Code	Description
Principal growth stage 3: Shoot development[1]	
31	Beginning of shoot growth: axes of developing shoots visible
32	Shoots about 20% of final length
33	Shoots about 30% of final length
3 .	Stages continuous till . . .
39	Shoots about 90% of final length
Principal growth stage 5: Inflorescence emergence	
51	Inflorescence buds and leaf buds swelling: buds closed, light brown scales visible
53	Bud burst: scales separated light green but sections visible
54	Green or red leaf tips above bud scales
55	First flower buds (compact raceme) visible beside unfolded leaves
56	Beginning of raceme elongation
57	First flower bud separated on elongating raceme
59	Grape stage: all flower buds separated
Principal growth stage 6: Flowering	
60	First flowers open
61	Beginning of flowering: about 10% of flowers open
65	Full flowering: at least 50% of flowers open, first petals falling
67	Flowers fading: majority of petals fallen
69	End of flowering: all petals fallen
Principal growth stage 7: Development of fruit	
71	Beginning of fruit growth: first fruits visible at raceme base
72	20% of fruits formed
73	30% of fruits formed
74	40% of fruits formed
75	50% of fruits formed
76	60% of fruits formed
77	70% of fruits formed
78	80% of fruits formed
79	90% of fruits formed

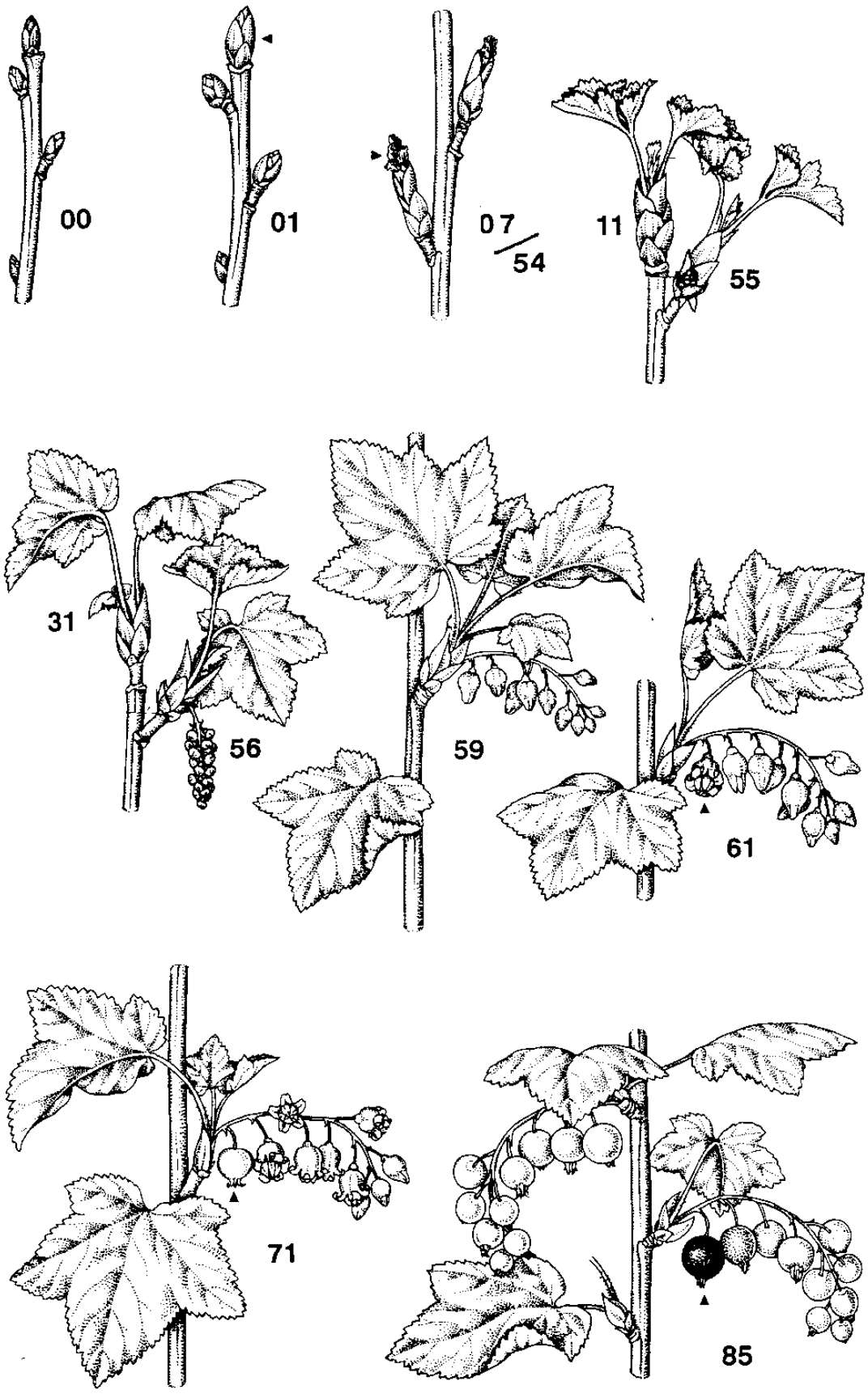
[1] From terminal bud

Currants Meier et al., 1994

Phenological growth stages and BBCH-identification keys of currants

Code	Description
Principal growth stage 8: Maturity of fruit and seed	
81	Beginning of ripening: change to cultivar-specific fruit color
85	Advanced ripening: first berries at base of racemes have cultivar-specific color
87	Fruit ripe for picking: most berries ripe
89	Berries at base of racemes tending to drop (beginning of fruit abscission)
Principal growth stage 9: Senescence, beginning of dormancy	
91	Shoot growth completed; terminal bud developed; foliage still fully green
92	Leaves begin to discolour
93	Beginning of leaf fall
95	50% of leaves discoloured or fallen
97	All leaves fallen
99	Harvested product

Currants



Strawberry Meier et al., 1994

Phenological growth stages and BBCH-identification keys of strawberry
(*Fragaria ananassa* Duch.)

Code	Description
Principal growth stage 0: Sprouting/Bud development	
00	Dormancy: Leaves prostrate and partly dead
03	Main bud swelling
Principal growth stage 1: Leaf development	
10	First leaf emerging
11	First leaf unfolded
12	2nd leaf unfolded
13	3rd leaf unfolded[1]
1 .	Stages continuous till . . .
19	9 or more leaves unfolded
Principal growth stage 4: Development of stolons and young plants	
41	Beginning of stolon (runner) formation: stolons visible (about 2 cm long)
42	First daughter plant visible
43	Beginning of root development in first daughter plant
45	First daughter plant with roots (ready for planting)
49	Several daughter plants with roots (ready for planting)
Principal growth stage 5: Inflorescence emergence	
55	First set flowers at the bottom of the rosette
56	Inflorescence elongating
57	First flower buds emerged (still closed)
58	Early balloon stage: first flowers with petals forming a hollow ball
59	Most flowers with petals forming a hollow ball
Principal growth stage 6: Flowering	
60	First flowers open (primary or A-flower)
61	Beginning of flowering: about 10% of flowers open
65	Full flowering: secondary (B) and tertiary (C) flowers open, first petals falling
67	Flowers fading: majority of petals fallen

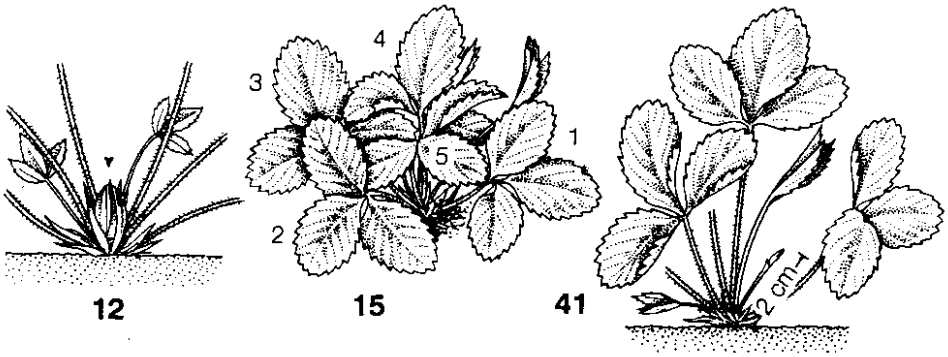
[1] Normally after the three leaf stage the bud development occurs in principal growth stage 5

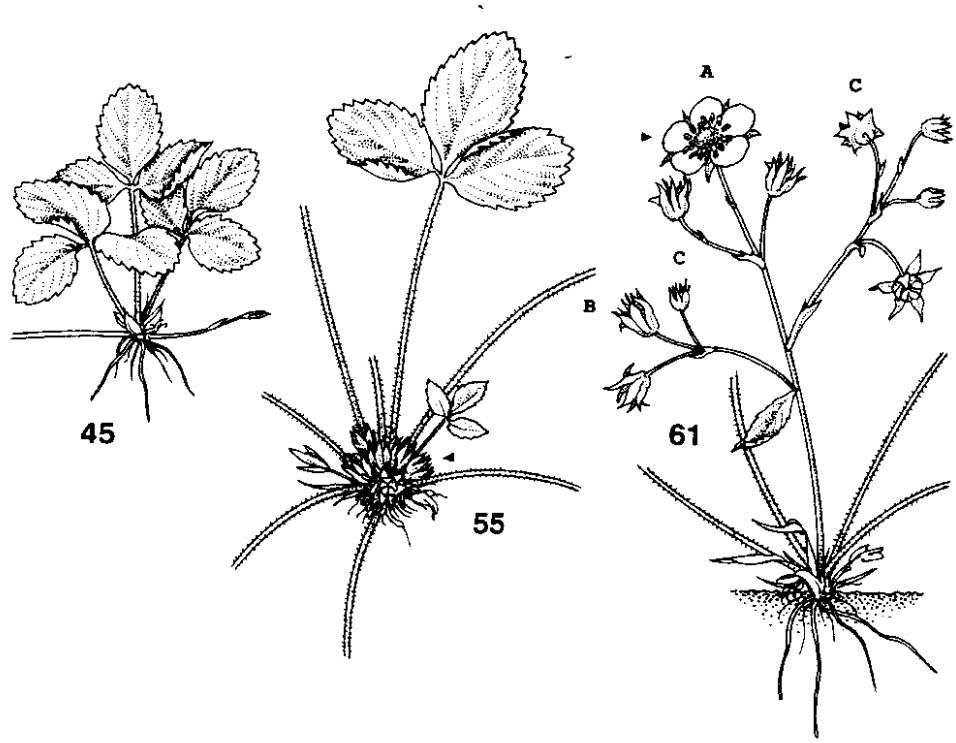
Strawberry Meier et al., 1994

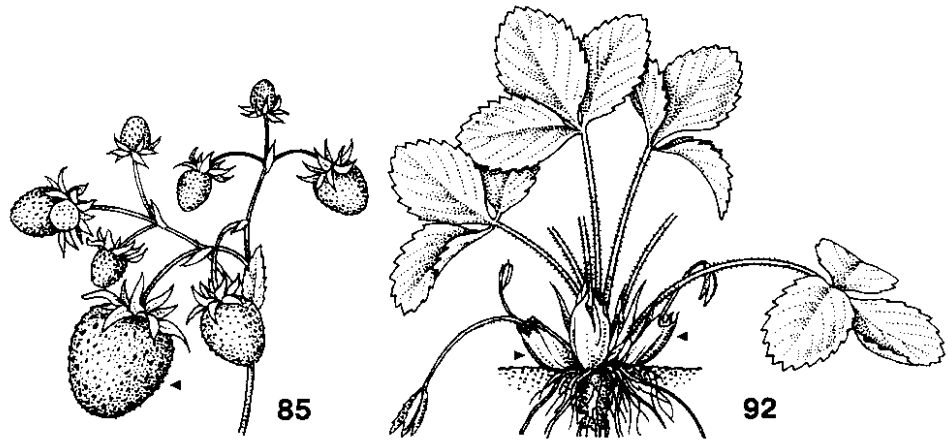
Phenological growth stages and BBCH-identification keys of strawberry

Code	Description
Principal growth stage 7: Development of fruit	
71	Receptacle protruding from sepal whorl
73	Seeds clearly visible on receptacle tissue
Principal growth stage 8: Maturity of fruit	
81	Beginning of ripening: most fruits white in colour
85	First fruits have cultivar-specific colour
87	Main harvest: more fruits coloured
89	Second harvest: more fruits coloured
Principal growth stage 9: Senescence, beginning of dormancy	
91	Beginning of axillary bud formation
92	New leaves with smaller lamina and shortened stalk visible
93	Old leaves dying, young leaves curling; old leaves of cultivarspecific colour
97	Old leaves dead

Strawberries







Citrus Agusti et al., 1995

Phenological growth stages and BBCH-identification keys of citrus
(*Citrus* spp. L.),

Code	Description
Principal growth stage 0: Sprouting/Bud development	
00	Dormancy: leaf and inflorescence buds undifferentiated, closed and covered by green scales
01	Beginning of bud swelling
03	End of bud swelling: green scales slightly separated
07	Beginning of bud burst
09	Green leaf tips visible
Principal growth stage 1: Leaf development	
10	First leaves separating: green scales slightly open, leaves emerging
11	First leaves visible[1]
15	More leaves visible, not yet at full size
19	First leaves fully expanded
Principal growth stage 3: Shoot development	
31	Beginning of shoot growth: axes of developing shoots visible
32	Shoots about 20% of final length
39	Shoots about 90% of final length
Principal growth stage 5: Inflorescence emergence	
51	Inflorescence buds swelling: buds closed, light green scales visible
53	Bud burst: scales separated, floral tips visible
55	Flowers visible, still closed (green bud), borne on single or multiflowered leafy or leafless inflorescences
56	Flower petals elongating; sepals covering half corolla (white bud)
57	Sepals open: petal tips visible; flowers with white or purplish petals, still closed
59	Most flowers with petals forming a hollow ball

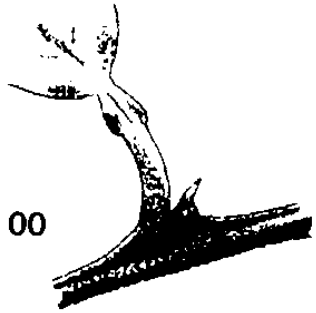
[1] In Citrus the term “visible” replaces “unfolded” used for other fruit species. Leaf unfolding takes place precociously in citrus

Citrus Agusti et al., 1995

Phenological growth stages and BBCH-identification keys of citrus

Code	Description
Principal growth stage 6: Flowering	
60	First flowers open
61	Beginning of flowering: about 10% of flowers open
65	Full flowering: 50% of flowers open; first petals falling
67	Flowers fading: majority of petals fallen
69	End of flowering: all petals fallen
Principal growth stage 7: Development of fruit	
71	Fruit set; beginning of ovary growth; beginning of fruitlets abscission
72	Green fruit surrounded by sepal crown
73	Some fruits slightly yellow: beginning of physiological fruit drop
74	Fruits about 40% of final size. Dark green fruit: end of physiological fruit drop
79	Fruits about 90% of final size
Principal growth stage 8: Maturity of fruit	
81	Beginning of fruit colouring (colour-break)
83	Fruit ripe for picking; fruit has not yet developed variety-specific colour
85	Advanced ripening; increase in intensity of variety-specific colour
89	Fruit ripe for consumption; fruit has typical taste and firmness; beginning of senescence and fruit abscission
Principal growth stage 9: Senescence, beginning of dormancy	
91	Shoot growth complete; foliage fully green
93	Beginning of senescense and abscission of old leaves
97	Winter dormancy period

Citrus



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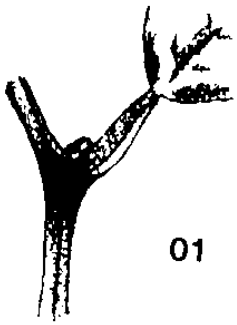

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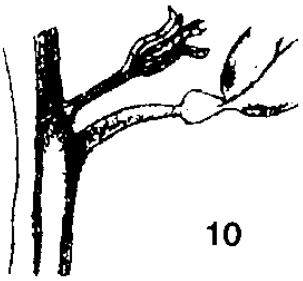

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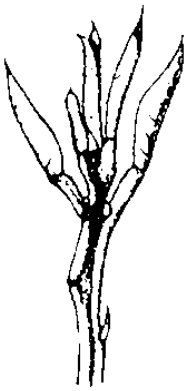

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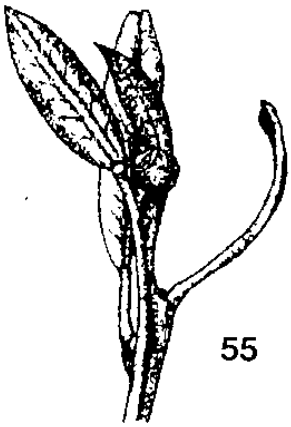

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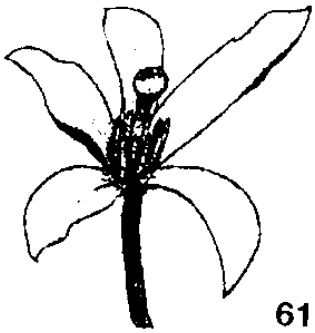

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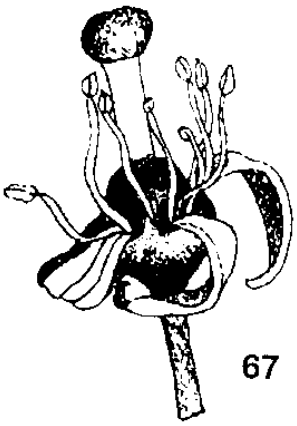

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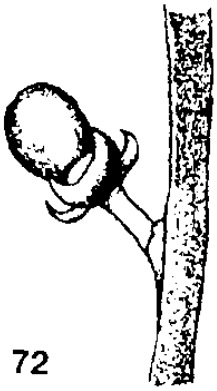

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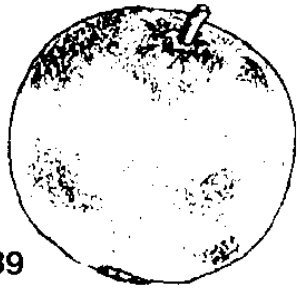

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Grapevine Lorenz et al., 1994

Phenological growth stages and BBCH-identification keys of grapevine
(*Vitis vinifera* L. ssp. *vinifera*)

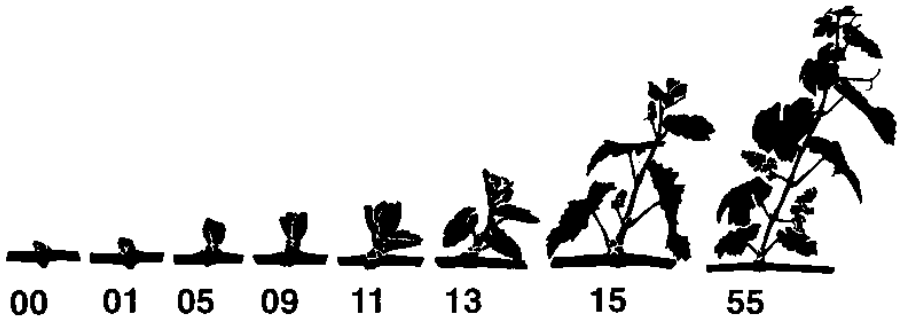
Code	Description
Principal growth stage 0: Sprouting/Bud development	
00	Dormancy: winter buds pointed to rounded, light or dark brown according to cultivar; bud scales more or less closed according to cultivar
01	Beginning of bud swelling: buds begin to expand inside the bud scales
03	End of bud swelling: buds swollen, but not green
05	"Wool stage": brown wool clearly visible
07	Beginning of bud burst: green shoot tips just visible
08	Bud burst: green shoot tips clearly visible
Principal growth stage 1: Leaf development	
11	First leaf unfolded and spread away from shoot
12	2nd leaves unfolded
13	3rd leaves unfolded
1 .	Stages continuous till . . .
19	9 or more leaves unfolded
Principal growth stage 5: Inflorescence emerge	
53	Inflorescences clearly visible
55	Inflorescences swelling, flowers closely pressed together
57	Inflorescences fully developed; flowers separating
Principal growth stage 6: Flowering	
60	First flowerhoods detached from the receptacle
61	Beginning of flowering: 10% of flowerhoods fallen
62	20% of flowerhoods fallen
63	Early flowering: 30% of flowerhoods fallen
64	40% of flowerhoods fallen
65	Full flowering: 50% of flowerhoods fallen
66	60% of flowerhoods fallen
67	70% of flowerhoods fallen
68	80% of flowerhoods fallen
69	End of flowering

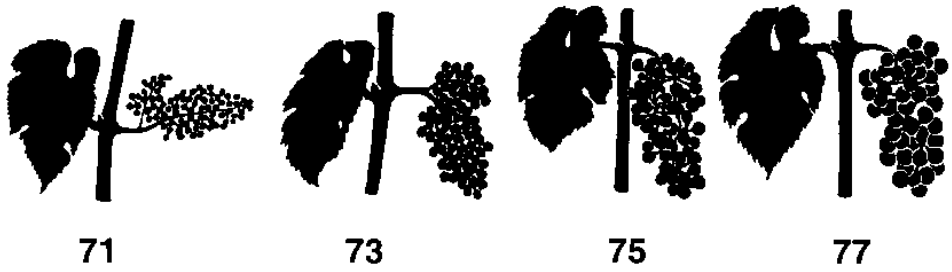
Grapevine Lorenz et al., 1994

Phenological growth stages and BBCH-identification keys of grapevine

Code	Description
Principal growth stage 7: Development of fruits	
71	Fruit set: young fruits begin to swell, remains of flowers lost
73	Berries groat-sized, bunches begin to hang
75	Berries pea-sized, bunches hang
77	Berries beginning to touch
79	Majority of berries touching
Principal growth stage 8: Ripening of berries	
81	Beginning of ripening: berries begin to develop variety-specific colour
83	Berries developing colour
85	Softening of berries
89	Berries ripe for harvest
Principal growth stage 9: Senescence	
91	After harvest; end of wood maturation
92	Beginning of leaf discolouration
93	Beginning of leaf-fall
95	50% of leaves fallen
97	End of leaf-fall
99	Harvested product

Grapevine





Soybean Munger et al.

Phenological growth stages and BBCH-identification keys of the soybean
(*Glycine max* L. Merr.)

Code		Description
2- and 3digit		
Principal growth stage 0: Germination		
00	000	Dry seed
01	001	Beginning of seed imbibition
03	003	Seed imbibition complete
05	005	Radicle emerged from seed
06	006	Elongation of radicle; formation of root hairs
07	007	Hypocotyl with cotyledons breaking through seed coat
08	008	Hypocotyl reaches the soil surface; hypocotyl arch visible
09	009	Emergence: hypocotyl with cotyledons emerged above soil surface (“cracking stage”)
2- and 3digit		
Principal growth stage 1: Leaf development (Main shoot)		
10	100	Cotyledons completely unfolded
11	101	First pair of true leaves unfolded (unifoliolate leaves on the first node)
12	102	Trifoliolate leaf on the 2nd node unfolded
13	103	Trifoliolate leaf on the 3rd node unfolded
1 .	10 .	Stages continuous till . . .
19	109	Trifoliolate leaf on the 9th node unfolded. No side shoots visible[1]
	110	Trifoliolate leaf on the 10th node unfolded[1]
	111	Trifoliolate leaf on the 11th node unfolded[1]
	112	Trifoliolate leaf on the 12th node unfolded[1]
	113	Trifoliolate leaf on the 13th node unfolded[1]
	11 .	Stages continuous till . . .
	119	Trifoliolate leaf on the 19th node unfolded[1]

1 The side shoot development may occur earlier, in this case continue with the principal growth stage 2

Soybean Munger et al.

Phenological growth stages and BBCH-identification keys of the soybean

Code		Description
2- and 3digit		
Principal growth stage 2: Formation of side shoots		
21	201	First side shoot visible
22	202	2nd side shoot of first order visible
23	203	3rd side shoot of first order visible
2 .	20 .	Stages continuous till . . .
29	209	9 or more side shoots of first order visible (2 digit) 9th side shoot of first order visible (3 digit)
	210	10th side shoot of first order visible
	221	First side shoot of 2nd order visible
	22 .	Stages continuous till . . .
	229	9th side shoot of 2nd order visible
	2N1	First side shoot of Nth order visible
	2N9	9th side shoot of Nth order visible
2- and 3digit		
Principal growth stage 4: Development of harvestable vegetative plant parts Main shoot		
49	409	Harvestable vegetative plant parts have reached final size (Cutting of soybean plants for feeding purposes)
2- and 3digit		
Principal growth stage 5: Inflorescence emergence (Main shoot)		
51	501	First flower buds visible
55	505	First flower buds enlarged
59	509	First flower petals visible; flower buds still closed

Soybean Munger et al.

Phenological growth stages and BBCH-identification keys of the soybean

Code		Description
2- and 3digit		
Principal growth stage 6: Flowering (Main shoot)		
60	600	First flowers opened (sporadically in population)
61	601	Beginning of flowering: about 10% of flowers open[2] Beginning of flowering[3]
62	602	About 20% of flowers open[2]
63	603	About 30% of flowers open[2]
64	604	About 40% of flowers open[2]
65	605	Full flowering: about 50% of flowers open[2] Main period of flowering[3]
66	606	About 60% of flowers open[2]
67	607	Flowering declining[2]
69	609	End of flowering: first pods visible (approx. 5 mm length)[2]
2- and 3digit		
Principal growth stage 7: Development of fruits and seeds		
70	700	First pod reached final length (15–20 mm)
71	701	About 10% of pods have reached final length (15–20 mm)[2] Beginning of pod development[3]
72	702	About 20% of pods have reached final length (15–20 mm)[2]
73	703	About 30% of pods have reached final length (15–20 mm)[2] Beginning of pod filling[3]
74	704	About 40% of pods have reached final length (15–20 mm)[2]
75	705	About 50% of pods have reached final length (15–20 mm). Continuation of pod filling.[2] Main period of pod development. Continuation of pod filling[3]
77	707	About 70% of pods have reached final length (15–20 mm); Advanced pod filling.[2] Advanced pod filling[3]
79	709	Approx. all pods have reached final length (15–20 mm). Seeds filling the cavity of the majority of pods[2, 3]

[2] This definition refers to determinate varieties
[3] This definition refers to indeterminate varieties

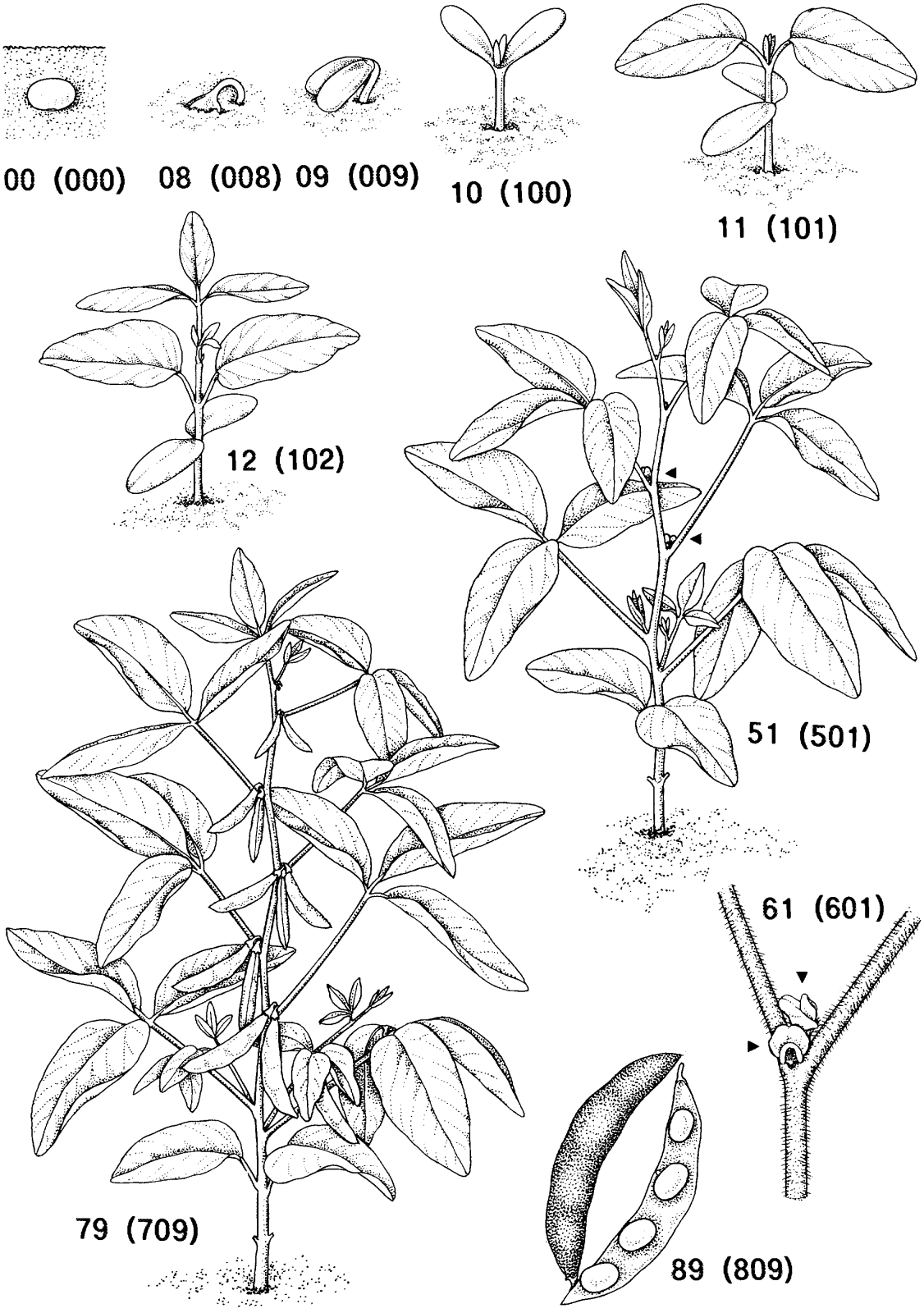
Soybean Munger et al.

Phenological growth stages and BBCH-identification keys of the soybean

Code		Description
2- and 3digit		
Principal growth stage 8: Ripening of fruits and seeds		
80	800	First pod ripe, beans final colour, dry and hard
81	801	Beginning of ripening; about 10% of pods are ripe, beans final colour, dry and hard.[2] Beginning of pod and seed ripening[3]
82	802	About 20% of pods are ripe; beans final colour, dry and hard[2]
83	803	About 30% of pods are ripe; beans final colour, dry and hard[2]
84	804	About 40% of pods are ripe; beans final colour, dry and hard[2]
85	805	Advanced ripening; about 50% of pods are ripe ; beans final colour, dry and hard.[2] Main period of pod and seed ripening[3]
86	806	About 60% of pods are ripe; beans final colour, dry and hard[2]
87	807	About 70% of pods are ripe; beans final colour, dry and hard[2]
88	808	About 80% of pods are ripe; beans final colour, dry and hard[2]
89	809	Full maturity: approx. all pods are ripe; beans final colour, dry and hard (= Harvest maturity).[2] Majority of pods are ripe; beans final colour, dry and hard[3]
2- and 3digit		
Principal growth stage 9: Senescence		
91	901	About 10% of leaves discoloured or fallen
92	902	About 20% of leaves discoloured or fallen
93	903	About 30% of leaves discoloured or fallen
94	904	About 40% of leaves discoloured or fallen
95	905	About 50% of leaves discoloured or fallen
96	906	About 60% of leaves discoloured or fallen
97	907	Above ground parts of plants dead
99	909	Harvested product (seeds)

[2] This definition refers to determinate varieties
[3] This definition refers to indeterminate varieties

Soybean


00 (000)
08 (008)
09 (009)
10 (100)
11 (101)
12 (102)
51 (501)
61 (601)
79 (709)
89 (809)

Cotton Munger et al.

Phenological growth stages and BBCH-identification keys of the cotton
(*Gossypium hirsutum* L.)

Code	Description
	Principal growth stage 0: Germination
00	Dry seed
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from seed
06	Elongation of radicle
07	Hypocotyl with cotyledons breaking through seed coat
08	Hypocotyl with cotyledons growing towards soil surface
09	Emergence: hypocotyl with cotyledons breaking through soil surface (“crook stage”)
	Principal growth stage 1: Leaf development (Main shoot)
10	Cotyledons completely unfolded[1]
11	First true leaf unfolded[1]
12	2nd true leaf unfolded[1]
13	3rd true leaf unfolded[1]
1 .	Stages continuous till . . .
19	9 or more true leaves unfolded;[1] no side shoots visible[2]
	Principal growth stage 2: Formation of side shoots[3]
21	First vegetative side shoot (2nd order) visible
22	2 vegetative side shoots (2nd order) visible
23	3 vegetative side shoots (2nd order) visible
2 .	Stages continuous till . . .
29	9 or more vegetative side shoots (2nd order) visible

[1] Leaves are counted from the cotyledon node (= node 0)
[2] Side shoot development may occur earlier, if there is a vegetative side shoot continue with principal growth stage 2. If there is a reproductive side shoot (fruiting branch) continue with the principal growth stage 5
[3] Vegetative side shoots are counted from the cotyledon node

Cotton Munger et al.

Phenological growth stages and BBCH-identification keys of the cotton

Code	Description
Principal growth stage 3: Main stem elongation (Crop cover)	
31	Beginning of crop cover: 10% of plants meet between rows
32	20% of plants meet between rows
33	30% of plants meet between rows
34	40% of plants meet between rows
35	50% of plants meet between rows
36	60% of plants meet between rows
37	70% of plants meet between rows
38	80% of plants meet between rows
39	Canopy closure: 90% of the plants meet between rows
Principal growth stage 5: Inflorescence emergence (Main shoot)	
51	First floral buds detectable (“pin-head square”)[4]
52	First floral buds visible (“match-head square”)[4]
55	Floral buds distinctly enlarged
59	Petals visible: floral buds still closed
Principal growth stage 6: Flowering	
60	First flowers opened (sporadically within the population)
61	Beginning of flowering (“Early bloom”): 5–6 blooms / 25 ft of row (= 5–6 blooms / 7,5 meter of row)
65	Full flowering: (“Mid bloom”): 11 and more blooms / 25 ft of row = 11 and more blooms / 7,5 meter of row
67	Flowering finishing: majority of flowers faded (“Late bloom”)
69	End of flowering
Principal growth stage 7: Development of fruits and seeds	
71	About 10% of bolls have attained their final size
72	About 20% of bolls have attained their final size
73	About 30% of bolls have attained their final size
74	About 40% of bolls have attained their final size
75	About 50% of bolls have attained their final size
76	About 60% of bolls have attained their final size
77	About 70% of bolls have attained their final size
78	About 80% of bolls have attained their final size
79	About 90% of bolls have attained their final size

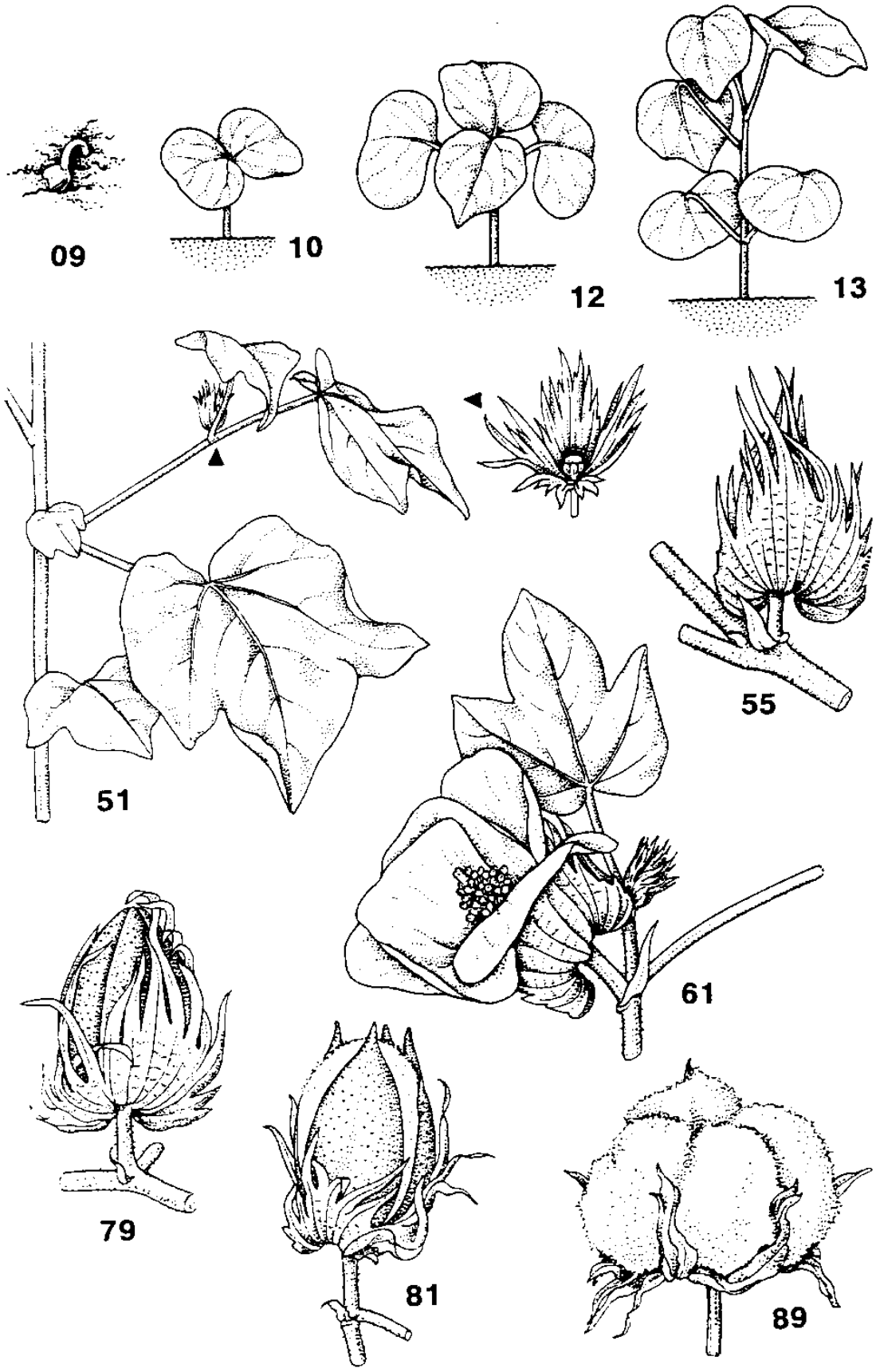
[4] “pin-head square” or “match-head square” is the first square which forms at the first fruiting position of the first fruiting branch

Cotton Munger et al.

Phenological growth stages and BBCH-identification keys of the cotton

Code	Description
Principal growth stage 8: Ripening of fruits and seeds	
80	Firstst open bolls on the first fruiting branches
81	Beginning of boll opening: about 10% of bolls open. Nodes Above White Flower (NAWF)
82	About 20% of bolls open
83	About 30% of bolls open. Nodes Above Cracked Boll (NACB)
84	About 40% of bolls open
85	About 50% of bolls open
86	About 60% of bolls open
87	About 70% of bolls open
88	About 80% of bolls open
89	About 90% of bolls open
Principal growth stage 9: Senescence	
91	About 10% of leaves discoloured or fallen
92	About 20% of leaves discoloured or fallen
93	About 30% of leaves discoloured or fallen
94	About 40% of leaves discoloured or fallen
95	About 50% of leaves discoloured or fallen
96	About 60% of leaves discoloured or fallen
97	Above ground parts of plant dead; plant dormant
99	Harvested product (bolls and seeds)

Cotton



Peanut Munger et al.

Phenological growth stages and BBCH-identification keys of the peanut
(*Arachis hypogaea* L.)

Code	Description
Principal growth stage 0: Germination	
00	Dry seed
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from seed
07	Hypocotyl with cotyledons breaking through seed coat
08	Hypocotyl reaches the soil surface; hypocotyl arch visible
09	Emergence: hypocotyl with cotyledons arising above soil surface (“cracking stage”)
Principal growth stage 1: Leaf development (Main shoot)	
10	Cotyledons completely unfolded[1]
11	First true leaf (pinnate) unfolded[1]
12	2nd true leaf (pinnate) unfolded[1]
13	3rd true leaf (pinnate) unfolded[1]
1 .	Stages continuous till . . .
19	9 or more true leaves unfolded.[1] No side shoots visible[2]
Principal growth stage 2: Formation of side shoots[3]	
21	1st side shoot visible
22	2nd side shoot visible
23	3rd side shoot visible
2 .	Stages continuous till . . .
29	9 or more side shoots visible
Principal growth stage 3: Main stem elongation (Crop cover)	
31	Beginning of crop cover: 10% of plants meets between rows
32	20% of plants meets between rows
33	30% of plants meets between rows
34	40% of plants meets between rows
35	50% of plants meets between rows
36	60% of plants meets between rows
37	70% of plants meets between rows
38	80% of plants meets between rows
39	Crop cover complete: 90% of plants meets between rows

[1] Leaves are counted from the cotyledon node (= node 0)
[2] Side shoot development may occur earlier; in this case continue with principal growth stage 2

Peanut Munger et al.

Phenological growth stages and BBCH-identification keys of the peanut

Code	Description
Principal growth stage 5: Inflorescence emergence	
51	First inflorescence buds visible
55	First individual flower buds visible
59	First flower petals visible. Flower buds still closed
Principal growth stage 6: Flowering	
61	Beginning of flowering
62	First carpophore pegs visible
63	Continuation of flowering
64	First carpophore pegs visibly elongated
65	Full flowering
66	First carpophore pegs penetrating the soil
67	Flowering declining[4]
68	Tip of first carpophore pegs growing horizontally in the soil
69	End of flowering[4]
Principal growth stage 7: Development of fruits and seeds	
71	Beginning of pod development: tip of first carpophore pegs swollen (at least twice the original diameter)
73	Continuation of pod development: beginning of pod filling: first pods have attained final size and are ripening
75	Main phase of pod development: continuation of pod filling
77	Advanced pod filling
79	Fresh seeds fill the cavity of the pods which have attained their final size

[4] Only for varieties with a determinate flowering period

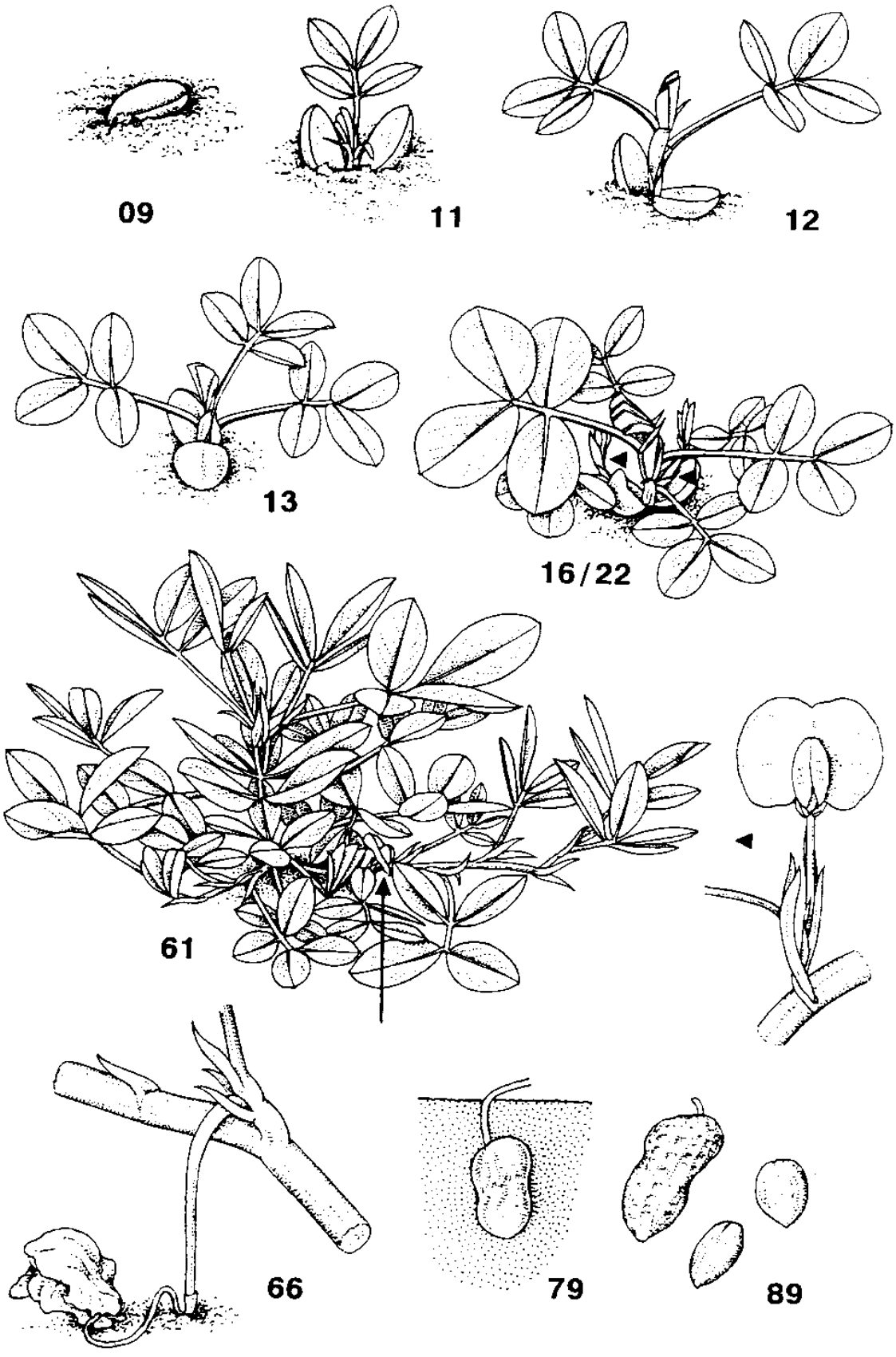
Peanut Munger et al.

Phenological growth stages and BBCH-identification keys of the peanut

Code	Description
Principal growth stage 8: Ripening of fruits and seeds[5]	
81	Beginning of ripening: about 10% of pods developed to final size are ripe
82	About 20% of pods developed to final size are ripe
83	Continuation of ripening: about 30% of pods developed to final size are ripe
84	About 40% of pods developed to final size are ripe
85	Main phase of ripening: about 50% of pods developed to final size are ripe
86	About 60% of pods developed to final size are ripe
87	Advanced ripening: about 70% of pods developed to final size are ripe
88	About 80% of pods developed to final size are ripe
89	Full maturity: nearly all pods developed to final size are ripe
Principal growth stage 9: Senescence	
91	About 10% of above ground parts of plant dry
92	About 40% of above ground parts of plant dry
93	About 30% of above ground parts of plant dry
94	About 40% of above ground parts of plant dry
95	About 50% of above ground parts of plant dry
96	About 60% of above ground parts of plant dry
97	Above ground parts of plant dead
99	Harvested product

[5] Criteria of maturity: Pericarp hard, with distinct texture, can be split open easily; Testa (seed coat) dry, with cultivar-specific dark colour

Peanut



Hop Rossbauer et al., 1995

Phenological growth stages and BBCH-identification keys of hop
(*Humulus lupulus* L.)

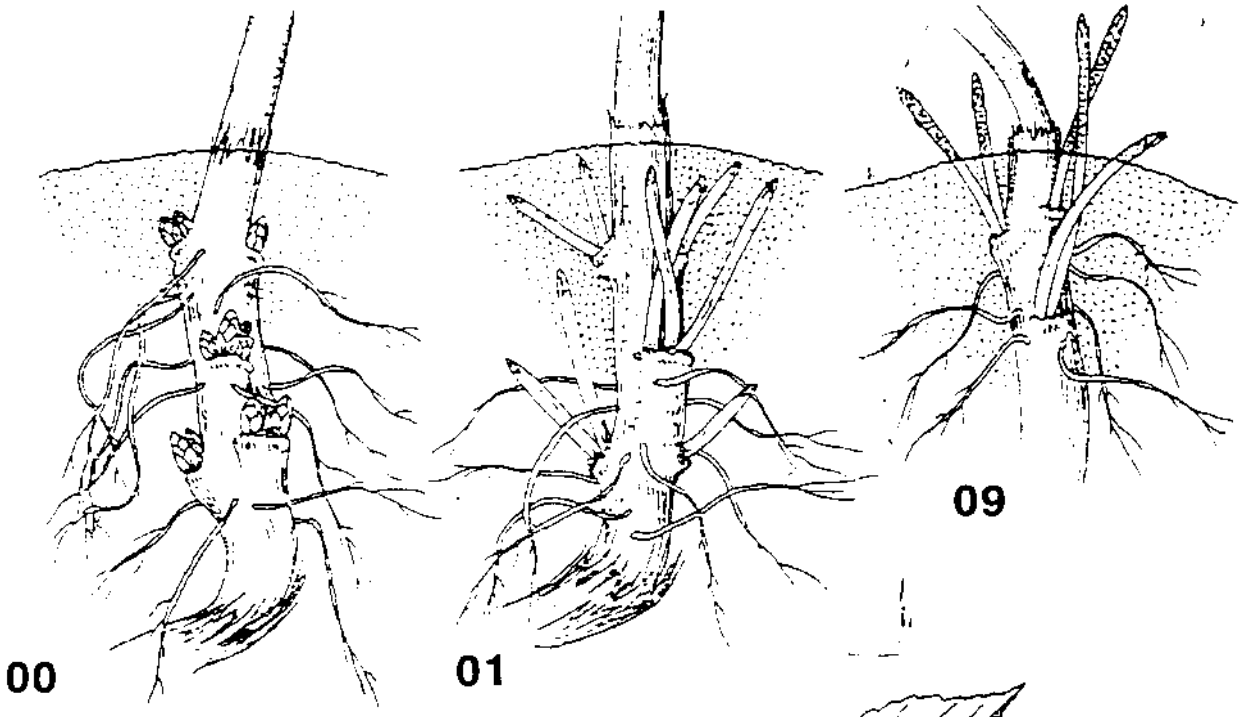
Code	Description
Principal growth stage 0: Sprouting	
00	Dormancy: rootstock without shoots (uncut)
01	Dormancy: rootstock without shoots (cut)
07	Rootstock with shoots (uncut)
08	Beginning of shoot-growth (rootstock cut)
09	Emergence: first shoots emerge at the soil surface
Principal growth stage 1: Leaf development	
11	First pair of leaves unfolded
12	2nd pair of leaves unfolded (beginning of twining)
13	3rd pair of leaves unfolded
1 .	Stages continuous till . . .
19	9 and more pairs of leaves unfolded
Principal growth stage 2: Formation of side shoots	
21	First pair of side shoots visible
22	2nd pair of side shoots visible
23	3rd pair of side shoots visible
2 .	Stages continuous till . . .
29	Nine and more pairs of side shoots visible (secondary side shoots occur)
Principal growth stage 3: Elongation of bines	
31	Bines have reached 10% of top wire height
32	Bines have reached 20% of top wire height
33	Bines have reached 30% of top wire height
3 .	Stages continuous till . . .
38	Plants have reached the top wire
39	End of bine growth
Principal growth stage 5: Inflorescence emergence	
51	Inflorescence buds visible
55	Inflorescence buds enlarged

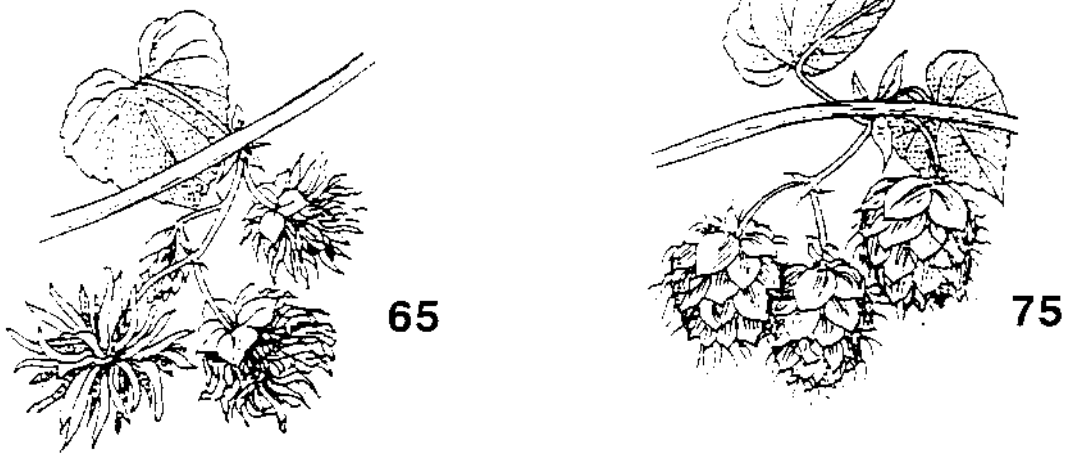
Hop Rossbauer et al., 1995

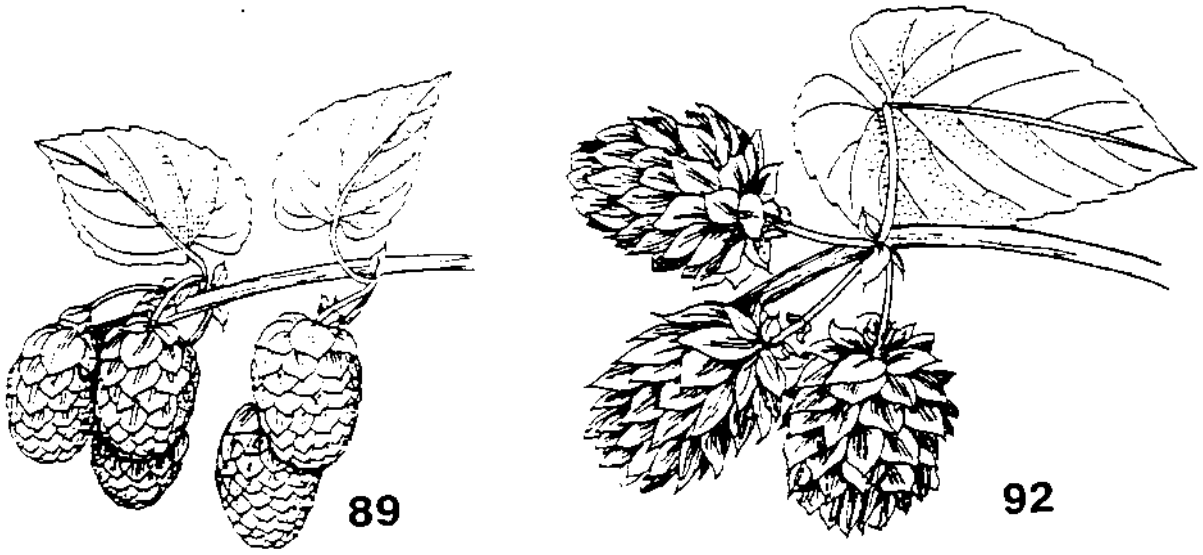
Phenological growth stages and BBCH-identification keys of hop

Code	Description
Principal growth stage 6: Flowering	
61	Beginning of flowering: about 10% of flowers open
62	About 20% of flowers open
63	About 30% of flowers open
64	About 40% of flowers open
65	Full flowering: about 50% of flowers open
66	About 60% of flowers open
67	About 70% of flowers open
68	About 80% of flowers open
69	End of flowering
Principal growth stage 7: Development of cones	
71	Beginning of cone development: 10% of inflorescences are cones
75	Cone development half way: all cones visible, cones soft, stigmas still present
79	Cone development complete: nearly all cones have reached full size
Principal growth stage 8: Maturity of cones	
81	Beginning of maturity: 10% of cones are compact
82	20% of cones are compact
83	30% of cones are compact
84	40% of cones are compact
85	Advanced maturity: 50% of cones are compact
86	60% of cones are compact
87	70% of cones are compact
88	80% of cones are compact
89	Cones ripe for picking: cones closed; lupulin golden; aroma potential fully developed
Principal growth stage 9: Senescence, entry into dormancy	
92	Overripeness: cones yellow-brown discoloured, aroma deterioration
97	Dormancy: leaves and stems dead

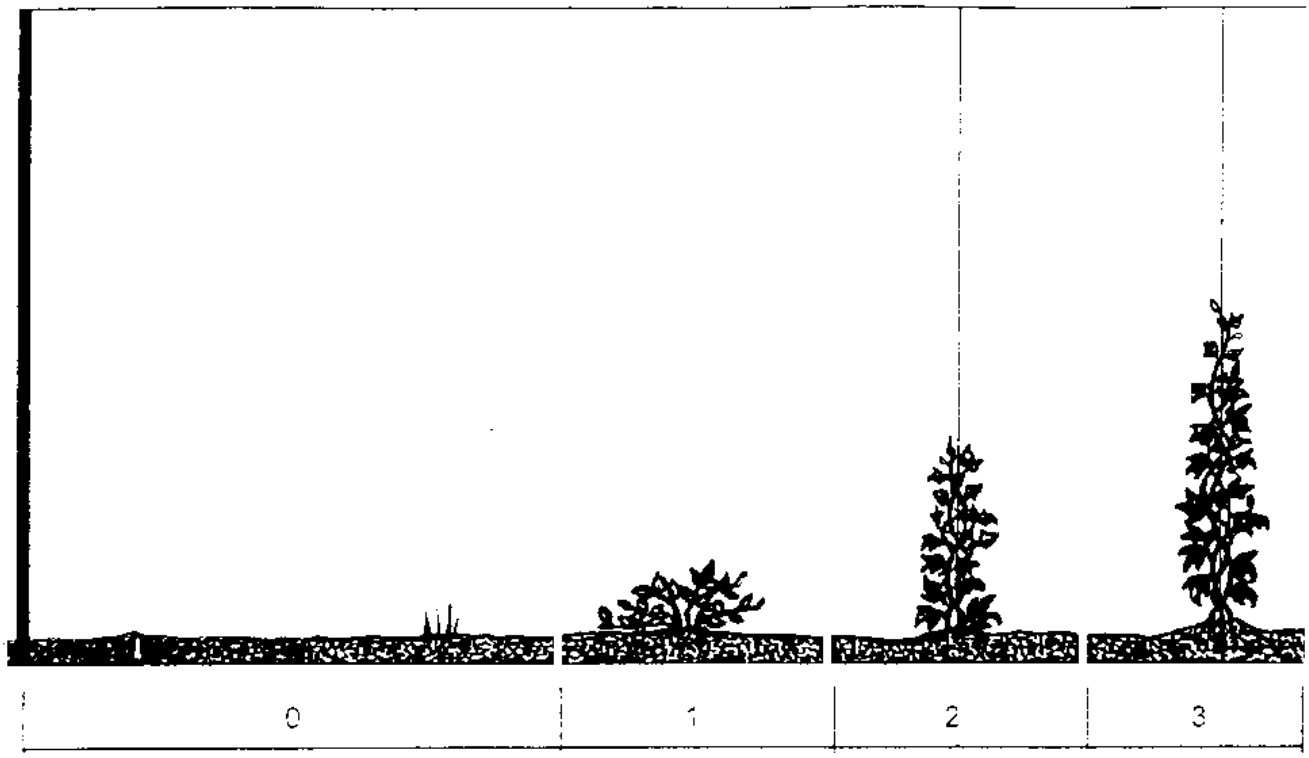
Hop

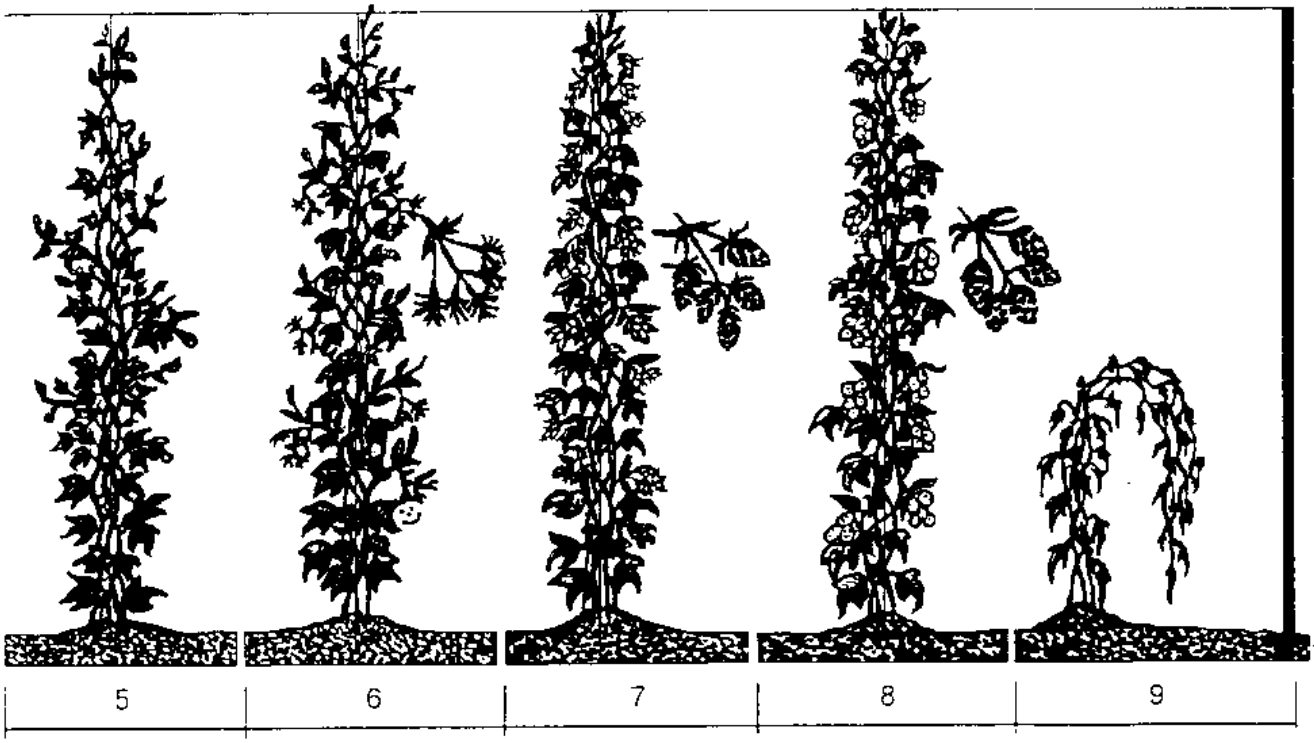






Hop





Bulb vegetables Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of bulb vegetables
(Onion = *Allium cepa* L., leek = *Allium porrum* L., garlic = *Allium sativum* L., shallot = *Allium ascalonicum* auct. non L.)

Code		Description
2- and 3digit		
Principal growth stage 0: Germination		
00	000	Dry seed,[1] dormant bulb [2]
01	000	Beginning of seed imbibition[1]
03	003	Seed imbibition complete[1]
05	005	Radicle emerged from seed.[1]
		Roots appearing[2]
07	007	Cotyledon breaking through seed coat[1]
09	009	Emergence: cotyledon breaks through soil surface.[1]
		Green shoot visible[2]
	010	Cotyledon visible as hook[1]
	011	Hook stage: hooked cotyledon green[1]
	012	Whip stage: cotyledon has whip-like form[1]
2- and 3digit		
Principal growth stage 1: Leaf development (Main shoot)		
10	100	Advanced whip stage: whip begins to die off[1]
11	101	First leaf (> 3 cm) clearly visible
12	102	2nd leaf (> 3 cm) clearly visible
13	103	3rd leaf (> 3 cm)
1 .	10 .	Stages continuous till . . .
19	109	9 or more leaves clearly visible
Principal growth stage 4: Development of harvestable vegetative plant parts		
41	401	Leaf bases begin to thicken or extend
43	403	30% of the expected bulb or shaft diameter reached
45	405	50% of the expected bulb or shaft diameter reached
47	407	Bolting begins; in 10% of the plants leaves bent over[3]
		70% of the expected shaft length and diameter reached[4]
48	408	Leaves bent over in 50% of plants[3]
49	409	Leaves dead, bulb top dry; dormancy[3] Growth complete; length and stem diameter typical for variety reached[4]

[1] Seed sown
[2] Onion sets, shallot and garlic
[3] For onions, garlic
[4] For leek

Bulb vegetables Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of bulb vegetables

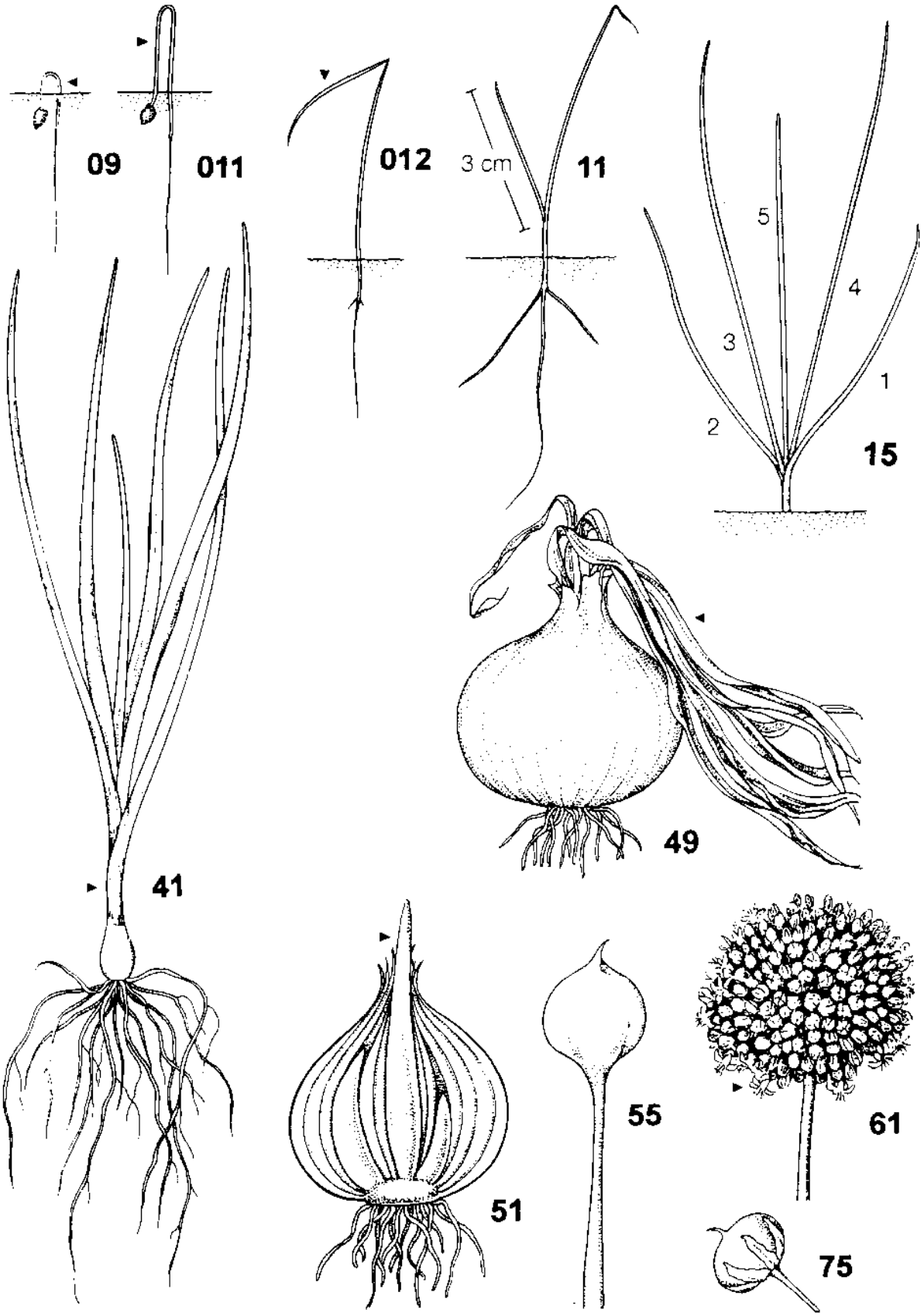
Code		Description
2- and 3digit		
Principal growth stage 5: Inflorescence emergence		
51	501	Onion bulb begins to elongate
53	503	30% of the expected length of flower stem reached
55	505	Flower stem at full length; sheath closed
57	507	Sheath burst open
59	509	First flower petals visible; flowers still closed
2- and 3digit		
Principal growth stage 6: Flowering		
60	600	First flowers open (sporadically)
61	601	Beginning of flowering: 10% of flowers open
62	602	20% of flowers open
63	603	30% of flowers open
64	604	40% of flowers open
65	605	Full flowering: 50% of flowers open
67	607	Flowering finishing: 70% of petals fallen or dry
69	609	End of flowering
2- and 3digit		
Principal growth stage 7: Development of fruit		
71	701	First capsules formed
72	702	20% of capsules formed
73	703	30% of capsules formed
74	704	40% of capsules formed
75	705	50% of capsules formed
76	706	60% of capsules formed
77	707	70% of capsules formed
78	708	80% of capsules formed
79	709	Capsule development complete; seeds pale
2- and 3digit		
Principal growth stage 8: Ripening of fruit and seed		
81	801	Beginning of ripening: 10% of capsules ripe
85	805	First capsules bursting
89	809	Fully ripe: seeds black and hard

Bulb vegetables Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of bulb vegetables

Code		Description
2- and 3digit		
Principal growth stage 9: Senescence		
92	902	Leaves and shoots beginning to discolour
95	905	50% of leaves yellow or dead
97	907	Plants or above ground parts dead
99	909	Harvested product (seeds)

Bulb vegetables



Root and stem vegetables Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of root and stem vegetables
(Carrot = *Daucus carota* L. ssp. *sativus*, celeriac = *Apium graveolens* L. var. *rapaceum* Gaud., kohlrabi = *Brassica oleracea* L. var. *gongylodes*, chicory = *Cichorium intybus* var. *foliosum,* radish = *Raphanus sativus* L. ssp., swede = *Brassica napus* L. ssp. *rapifera* Metzg., scorzonera = *Scorzonera hispanica* L.)

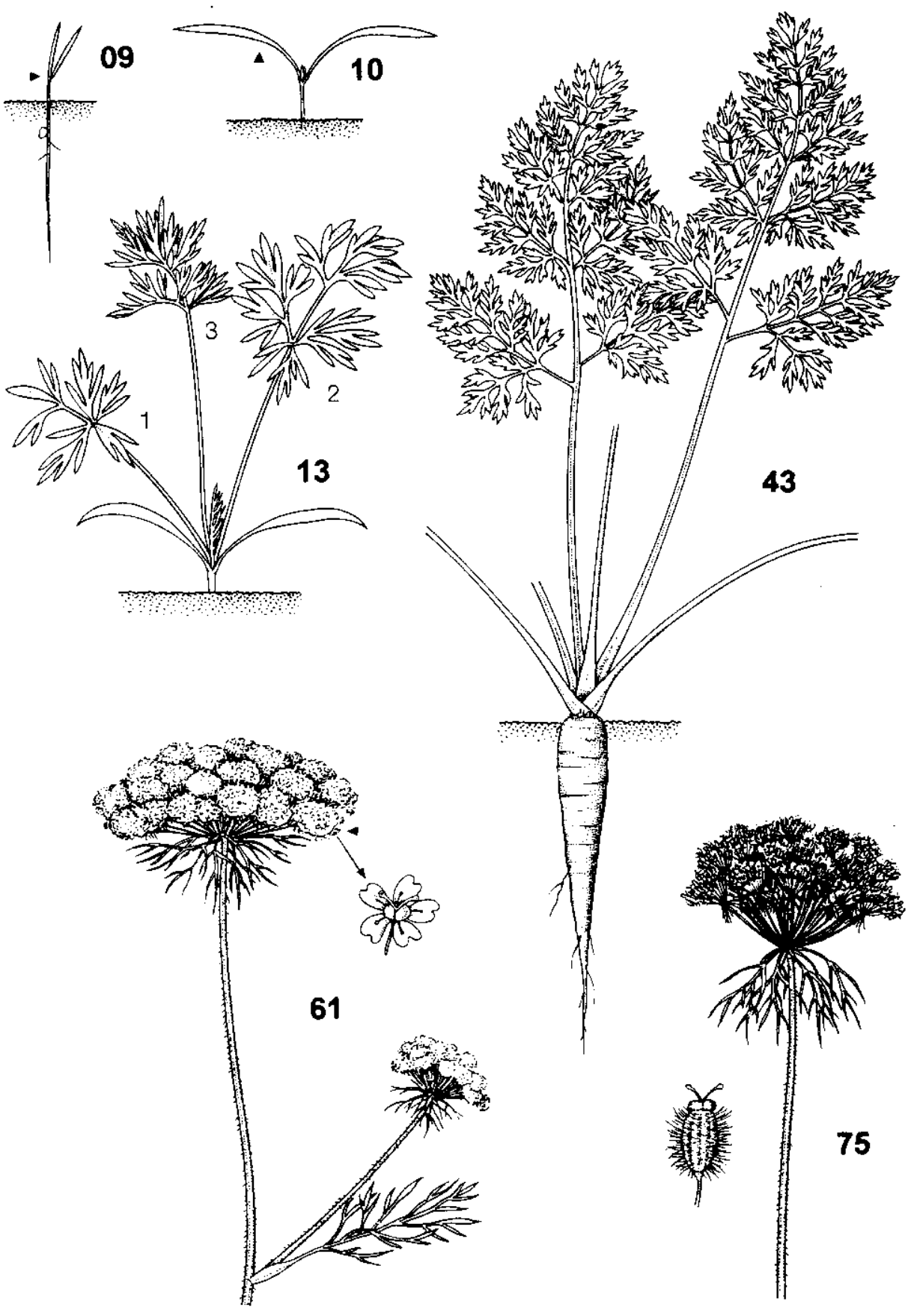
Code	Description
Principal growth stage 0: Germination	
00	Dry seed
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from seed
07	Hypocotyl with cotyledons breaking through seed coat
09	Emergence: cotyledons break through soil surface
Principal growth stage 1: Leaf development (Main shoot)	
10	Cotyledons completely unfolded; growing point or true leaf initial visible
11	First true leaf unfolded
12	2nd true leaf unfolded
13	3rd true leaf unfolded
1 .	Stages continuous till . . .
19	9 or more true leaves unfolded
Principal growth stage 4: Development of harvestable vegetative plant parts	
41	Roots beginning to expand (diameter > 0,5 cm)
42	20% of the expected root diameter reached
43	30% of the expected root diameter reached
44	40% of the expected root diameter reached
45	50% of the expected root diameter reached
46	60% of the expected root diameter reached
47	70% of the expected root diameter reached
48	80% of the expected root diameter reached
49	Expansion complete; typical form and size of roots reached
Principal growth stage 5: Inflorescence emergence	
51	Main shoot begins to elongate
53	30% of the expected height of the main shoot reached
55	First individual flowers of main inflorescence visible (still closed)
57	First individual flowers of secondary inflorescences visible (still closed)
59	First flower petals visible; flowers still closed

Root and stem vegetables Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of root and stem vegetables

Code	Description
Principal growth stage 6: Flowering	
60	First flowers open (sporadically)
61	Beginning of flowering: 10% of flowers open
62	20% of flowers open
63	30% of flowers open
64	40% of flowers open
65	Full flowering: 50% of flowers open
67	Flowering finishing: majority of petals fallen or dry
69	End of flowering
Principal growth stage 7: Development of fruit	
71	First fruits formed
72	20% of fruits have reached typical size
73	30% of fruits have reached typical size
74	40% of fruits have reached typical size
75	50% of fruits have reached typical size
76	60% of fruits have reached typical size
77	70% of fruits have reached typical size
78	80% of fruits have reached typical size
79	Fruits have reached typical size
Principal growth stage 8: Rispening of fruit and seed	
81	Beginning of ripening: 10% of fruits ripe, or 10% of seeds of typical colour, dry and hard
85	50% of the fruits ripe, or 50% of seeds of typical colour, dry and hard
89	Fully ripe: seeds on the whole plant of typical colour and hard
Principal growth stage 9: Senescence	
92	Leaves and shoots beginning to discolour
95	50% of leaves yellow or dead
97	Plants or above ground parts dead
99	Harvested product (seeds)

Root and stem vegetables



Leaf vegetables (forming heads) Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of leaf vegetables (forming heads)
(cabbage = *Brassica oleracea* L. var. *capitata* f. *alba* and *rubra,* chinese cabbage = *Brassica chinensis* L., lettuce = *Lactuca sativa* L. var. *capitata,* endive = *Cichorium endivia* L.)

Code	Description
Principal growth stage 0: Germination	
00	Dry seed
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from seed
07	Hypocotyl with cotyledons breaking through seed coat
09	Emergence: cotyledons break through soil surface
Principal growth stage 1: Leaf development (Main shoot)	
10	Cotyledons completely unfolded; growing point or true leaf initial visible
11	First true leaf unfolded
12	2nd true leaf unfolded
13	3rd true leaf unfolded
1 .	Stages continuous till . . .
19	9 or more true leaves unfolded
Principal growth stage 4: Development of harvestable vegetative plant parts	
41	Heads begin to form: the two youngest leaves do not unfold
42	20% of the expected head size reached
43	30% of the expected head size reached
44	40% of the expected head size reached
45	50% of the expected head size reached
46	60% of the expected head size reached
47	70% of the expected head size reached
48	80% of the expected head size reached
49	Typical size, form and firmness of heads reached
Principal growth stage 5: Inflorescence emergence	
51	Main shoot inside head begins to elongate
53	30% of the expected height of the main shoot reached
55	First individual flowers of main inflorescence visible (still closed)
57	First individual flowers of secondary inflorescences visible (still closed)
59	First flower petals visible; flowers still closed

Leaf vegetables (forming heads) Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of leaf vegetables (forming heads)

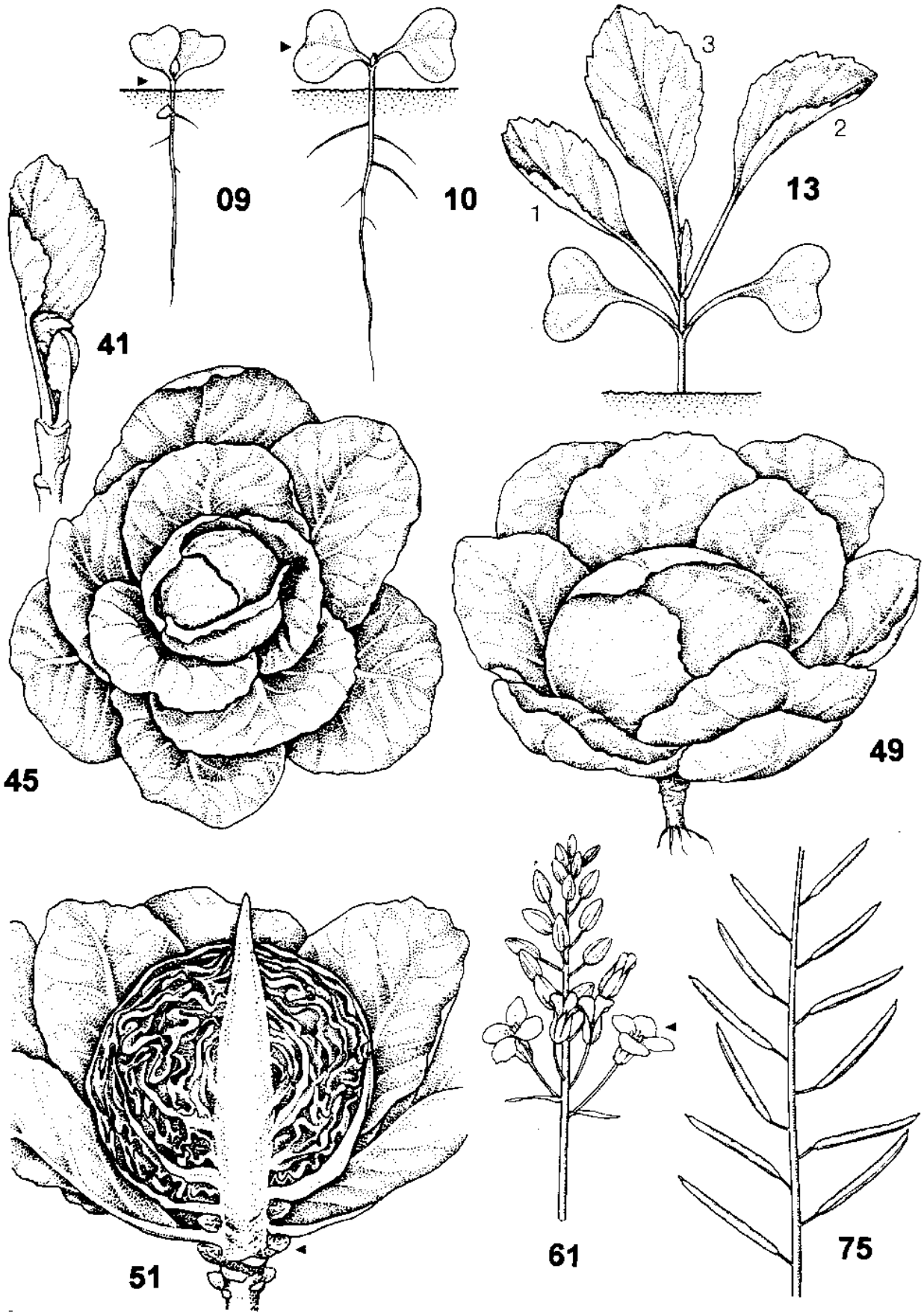
Code	Description
Principal growth stage 6: Flowering	
60	First flowers open (sporadically)
61	Beginning of flowering: 10% of flowers open
62	20% of flowers open
63	30% of flowers open
64	40% of flowers open
65	Full flowering: 50% of flowers open
67	Flowering finishing: majority of petals fallen or dry
69	End of flowering
Principal growth stage 7: Development of fruit	
71	First fruits formed
72	20% of fruits have reached typical size
73	30% of fruits have reached typical size
74	40% of fruits have reached typical size
75	50% of fruits have reached typical size
76	60% of fruits have reached typical size
77	70% of fruits have reached typical size
78	80% of fruits have reached typical size
79	Fruits have reached typical size
Principal growth stage 8: Ripening of fruit and seed	
81	Beginning of ripening: 10% of fruits ripe, or 10% of seeds of typical colour, dry and hard
82	20% of fruits ripe, or 20% of seeds of typical colour, dry and hard
83	30% of fruits ripe, or 30% of seeds of typical colour, dry and hard
84	40% of fruits ripe, or 40% of seeds of typical colour, dry and hard
85	50% of the fruits ripe, or 50% of seeds of typical colour, dry and hard
86	60% of fruits ripe, or 60% of seeds of typical colour, dry and hard
87	70% of fruits ripe, or 70% of seeds of typical colour, dry and hard
88	80% of fruits ripe, or 80% of seeds of typical colour, dry and hard
89	Fully ripe: seeds on the whole plant of typical colour and hard

Leaf vegetables (forming heads) Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of leaf vegetables (forming heads)

Code	Description
Principal growth stage 9: Senescence	
92	Leaves and shoots beginning to discolour
95	50% of leaves yellow or dead
97	Plants dead
99	Harvested product (seeds)

Leaf vegetables (forming heads)



Leaf vegetables (not forming heads)

Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of leaf vegetables not forming heads
(spinach = *Spinacia oleracea* L., loosehead lettuce = *Lactuca sativa* L. var. *crispa,* kale = *Brassica oleracea* L. var. *sabellica*)

Code	Description
Principal growth stage 0: Germination	
00	Dry seed
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from seed
07	Hypocotyl with cotyledons breaking through seed coat
09	Emergence: cotyledons break through soil surface
Principal growth stage 1: Leaf development (Main shoot)	
10	Cotyledons completely unfolded; growing point or true leaf initial visible
11	First true leaf unfolded
12	2nd true leaf unfolded
13	3rd true leaf unfolded
1 .	Stages continuous till . . .
19	9 or more true leaves unfolded
Principal growth stage 3: Stem elongation of rosette growth	
33	Leaf rosette has reached 30% of the expected diameter typical for the variety.[1] Main shoot has reached 30% of the expected height typical for the variety[2]
35	Leaf rosette has reached 50% of the expected diameter typical for the variety.[1] Main shoot has reached 50% of the expected height typical for the variety[2]
37	Leaf rosette has reached 70% of the expected diameter typical for the variety.[1] Main shoot has reached 70% of the expected height for the variety[2]
39	Rosette development completed[1] Main shoot has reached the height typical for the variety[2]

[1] For letucce varieties without head, spinach and species with rosette-type growth
[2] For kale and species without rosette growth

Leaf vegetables (not forming heads)

Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of leaf vegetables (not forming heads)

Code	Description
	Principal growth stage 4: Development of harvestable vegetative plant parts
41	10% of the leaf mass typical for the variety reached
42	20% of the leaf mass typical for the variety reached
43	30% of the leaf mass typical for the variety reached
44	40% of the leaf mass typical for the variety reached
45	50% of the leaf mass typical for the variety reached
46	60% of the leaf mass typical for the variety reached
47	70% of the leaf mass typical for the variety reached
48	80% of the leaf mass typical for the variety reached
49	Typical leaf mass reached
	Principal growth stage 5: Inflorescence emergence
51	Main shoot begins to elongate[1] Main inflorescence visible between uppermost leaves[2]
53	30% of the expected height of the main shoot reached
55	First individual flowers of main inflorescence visible (still closed)
59	First flower petals visible; flowers still closed
	Principal growth stage 6: Flowering
60	First flowers open (sporadically)
61	Beginning of flowering: 10% of flowers open
62	20% of flowers open
63	30% of flowers open
64	40% of flowers open
65	Full flowering: 50% of flowers open
67	Flowering finishing: majority of petals fallen or dry
69	End of flowering

[1] For letucce varieties without head, spinach and species with rosette-type growth
[2] For kale and species without rosette growth

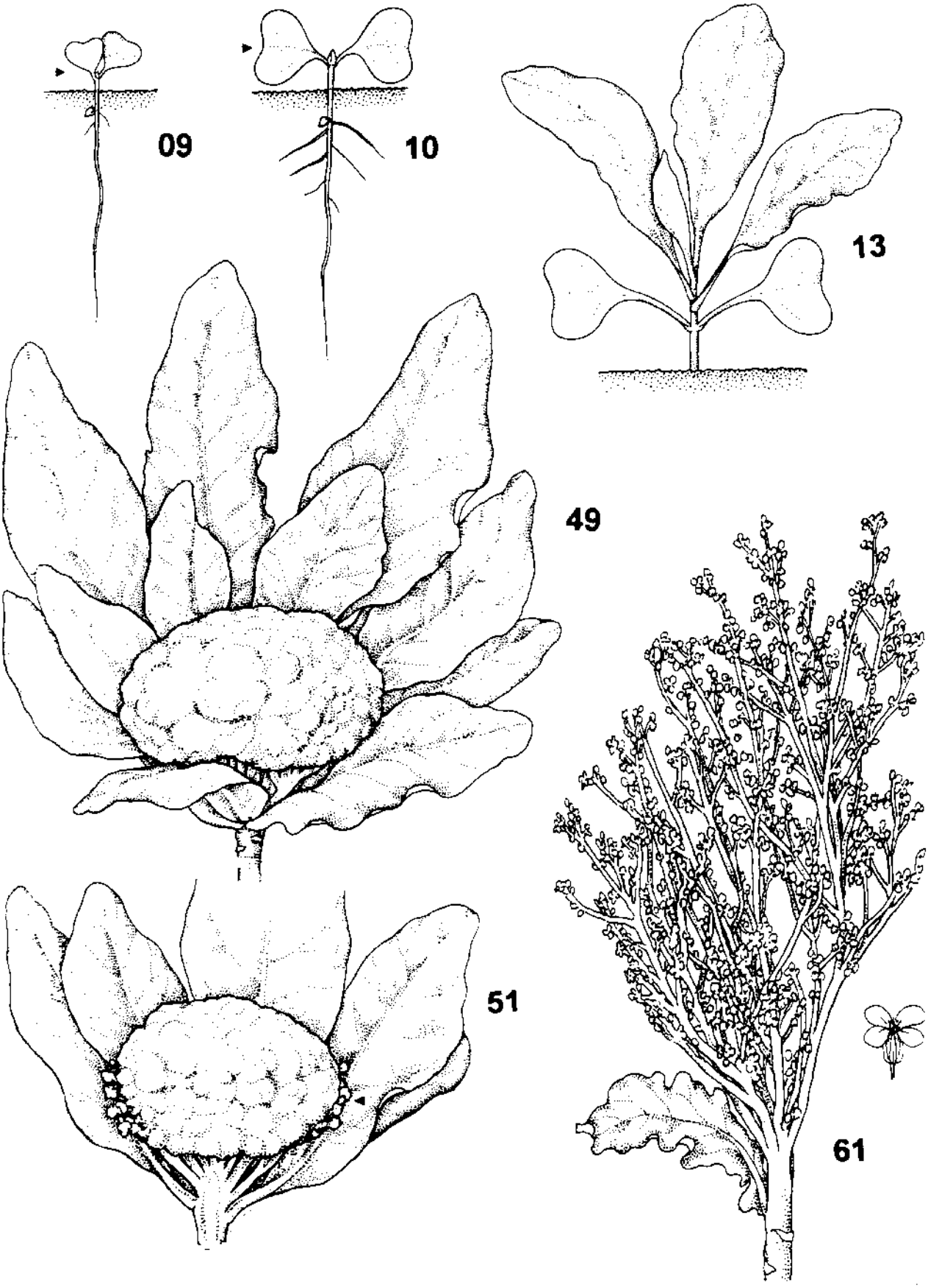
Leaf vegetables (not forming heads)

Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of leaf vegetables (not forming heads)

Code	Description
Principal growth stage 7: Development of fruit	
71	First fruits formed
72	20% of fruits have reached typical size
73	30% of fruits have reached typical size
74	40% of fruits have reached typical size
75	50% of fruits have reached typical size
76	60% of fruits have reached typical size
77	70% of fruits have reached typical size
78	80% of fruits have reached typical size
79	Fruits have reached typical size
Principal growth stage 8: Ripening of fruit and seed	
81	Beginning of ripening: 10% of fruits ripe, or 10% of seeds of typical colour, dry and hard
82	20% of fruits ripe, or 20% of seeds of typical colour, dry and hard
83	30% of fruits ripe, or 20% of seeds of typical colour, dry and hard
84	40% of fruits ripe, or 20% of seeds of typical colour, dry and hard
85	50% of fruits ripe, or 50% of seeds of typical colour, dry and hard
86	60% of fruits ripe, or 20% of seeds of typical colour, dry and hard
87	70% of fruits ripe, or 20% of seeds of typical colour, dry and hard
88	80% of fruits ripe, or 20% of seeds of typical colour, dry and hard
89	Fully ripe: seeds on the whole plant of typical colour and hard
Principal growth stage 9: Senescence	
92	Leaves and shoots beginning to discolor
95	50% of leaves yellow or dead
97	Plants dead
99	Harvested product (seeds)

Leaf vegetables (not forming heads)



Other brassica vegetables Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of other brassica vegetables
(Brussels sprout = *Brassica oleracea* L. var. *gemmifera* DC./Zenk., cauliflower = *Brassica oleracea* L. var. *botrytis*, broccoli = *Brassica oleracea* L. var. *italica* Plenck)

Code	Description
Principal growth stage 0: Germination	
00	Dry seed
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from seed
07	Hypocotyl with cotyledons breaking through seed coat
09	Emergence: cotyledons break through soil surface
Principal growth stage 1: Leaf development (Main shoot)	
10	Cotyledons completely unfolded; growing point or true leaf initial visible
11	First true leaf unfolded
12	2nd true leaf unfolded
13	3rd true leaf unfolded
1 .	Stages continuous till . . .
19	9 or more true leaves unfolded
Principal growth stage 2: Formation of side shoots	
21	First side shoot visible[1]
22	2nd side shoot visible[1]
23	3rd side shoot visible[1]
2 .	Stages continuous till . . .
29	9 or more side shoots visible[1]

[1] For broccoli

Other brassica vegetables Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of other brassica vegetables

Code	Description
Principal growth stage 3: Stem elongation of rosette growth	
31	Main shoot has reached 10% of the expected height typical for the variety[2]
32	Main shoot has reached 20% of the expected height typical for the variety[2]
33	Main shoot has reached 30% of the expected height typical for the variety[2]
34	Main shoot has reached 40% of the expected height typical for the variety[2]
35	Main shoot has reached 50% of the expected height typical for the variety[2]
36	Main shoot has reached 60% of the expected height typical for the variety[2]
37	Main shoot has reached 70% of the expected height typical for the variety[2]
38	Main shoot has reached 80% of the expected height typical for the variety[2]
39	Main shoot has reached the height typical for the variety[2]
Principal growth stage 4: Development of harvestable vegetative plant parts	
41	Lateral buds begin to develop[2] Cauliflower heads begin to form;width of growing tip > 1 cm[3]
43	First sprouts tightly closed[2] 30% of the expected head diameter reached[3]
45	50% of the sprouts tightly closed[2] 50% of the expected head diameter reached[3]
46	60% of the sprouts tightly closed[2] 60% of the expected head diameter reached[3]
47	70% of the sprouts tightly closed[2] 70% of the expected head diameter reached[3]
48	80% of the sprouts tightly closed[2] 80% of the expected head diameter reached[3]
49	Sprouts below terminal bud tightly closed[2] Typical size and form reached; head tightly closed[3]

[2] For brussels sprout
[3] For cauliflower and broccoli

Other brassica vegetables Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of other brassica vegetables

Code	Description
Principal growth stage 5: Inflorescence emergence	
51	Main inflorescence visible between uppermost leaves[2] Branches of inflorescence begin to elongate[3]
55	First individual flowers visible (still closed)
59	First flower petals visible; flowers still closed
Principal growth stage 6: Flowering	
60	First flowers open (sporadically)
61	Beginning of flowering: 10% of flowers open
62	20% of flowers open
63	30% of flowers open
64	40% of flowers open
65	Full flowering: 50% of flowers open
67	Flowering finishing: majority of petals fallen or dry
69	End of flowering
Principal growth stage 7: Development of fruit	
71	First fruits formed
72	20% of fruits have reached typical size
73	30% of fruits have reached typical size
74	40% of fruits have reached typical size
75	50% of fruits have reached typical size
76	60% of fruits have reached typical size
77	70% of fruits have reached typical size
78	80% of fruits have reached typical size
79	Fruits have reached typical size
Principal growth stage 8: Ripening of fruit and seed	
81	Beginning of ripening: 10% of fruits ripe
82	20% of fruits ripe
83	30% of fruits ripe
84	40% of fruits ripe
85	50% of fruits ripe
86	60% of fruits ripe
87	70% of fruits ripe
88	80% of fruits ripe
89	Fully ripe: seeds on the whole plant of typical color and hard

[2] For brussels sprout
[3] For cauliflower and broccoli

Other brassica vegetables Feller et al., 1995 a

Phenological growth stages and BBCH-identification keys of other brassica vegetables

Code	Description
Principal growth stage 9: Senescence	
92	Leaves and shoots beginning to discolour
95	50% of leaves yellow or dead
97	Plants dead
99	Harvested product (seeds)

Cucurbits Feller et al., 1995 b

Phenological growth stages and BBCH-identification keys of cucurbits
(Cucumber = *Cucumis sativus* L., melon = *Cucumis melo* L., pumpkin, marrow, squash = *Cucurbita pepo* L., calabash = *Cucurbita pepo* L. var. *giromontiina* Alef./Greb, water-melon = *Citrullus* var. *vulgaris* Schad.)

Code		Description
2 -and 3digit		
Principal growth stage 0: Germination		
00	000	Dry seed
01	001	Beginning of seed imbibition
03	003	Seed imbibition complete
05	005	Radicle emerged from seed
07	007	Hypocotyl with cotyledons breaking through seed coat
09	009	Emergence: cotyledons break through soil surface
2- and 3digit		
Principal growth stage 1: Leaf development		
10	100	Cotyledons completely unfolded
11	101	First true leaf on main stem fully unfolded
12	102	2nd true leaf on main stem unfolded
13	103	3rd true leaf on main stem unfolded
1 .	10 .	Stages continuous till . . .
19	109	9 or more leaves on main stem unfolded (2digit) 9th leaf unfolded on main stem (3digit)
–	110	10th leaf on main stem unfolded
–	11 .	Stages continuous till . . .
–	119	19th leaf on main stem unfolded
2 -and 3digit		
Principal growth stage 2: Formation of side shoots		
21	201	First primary side shoot visible
22	202	2nd primary side shoot visible
2 .	20 .	Stages continuous till . . .
29	209	9 or more primary side shoots visible
–	221	First secondary side shoot visible
–	22 .	Stages continuous till . . .
–	229	9th secondary side shoot visible
–	231	First tertiary side shoot visible

Cucurbits Feller et al., 1995 b

Phenological growth stages and BBCH-identification keys of cucurbits

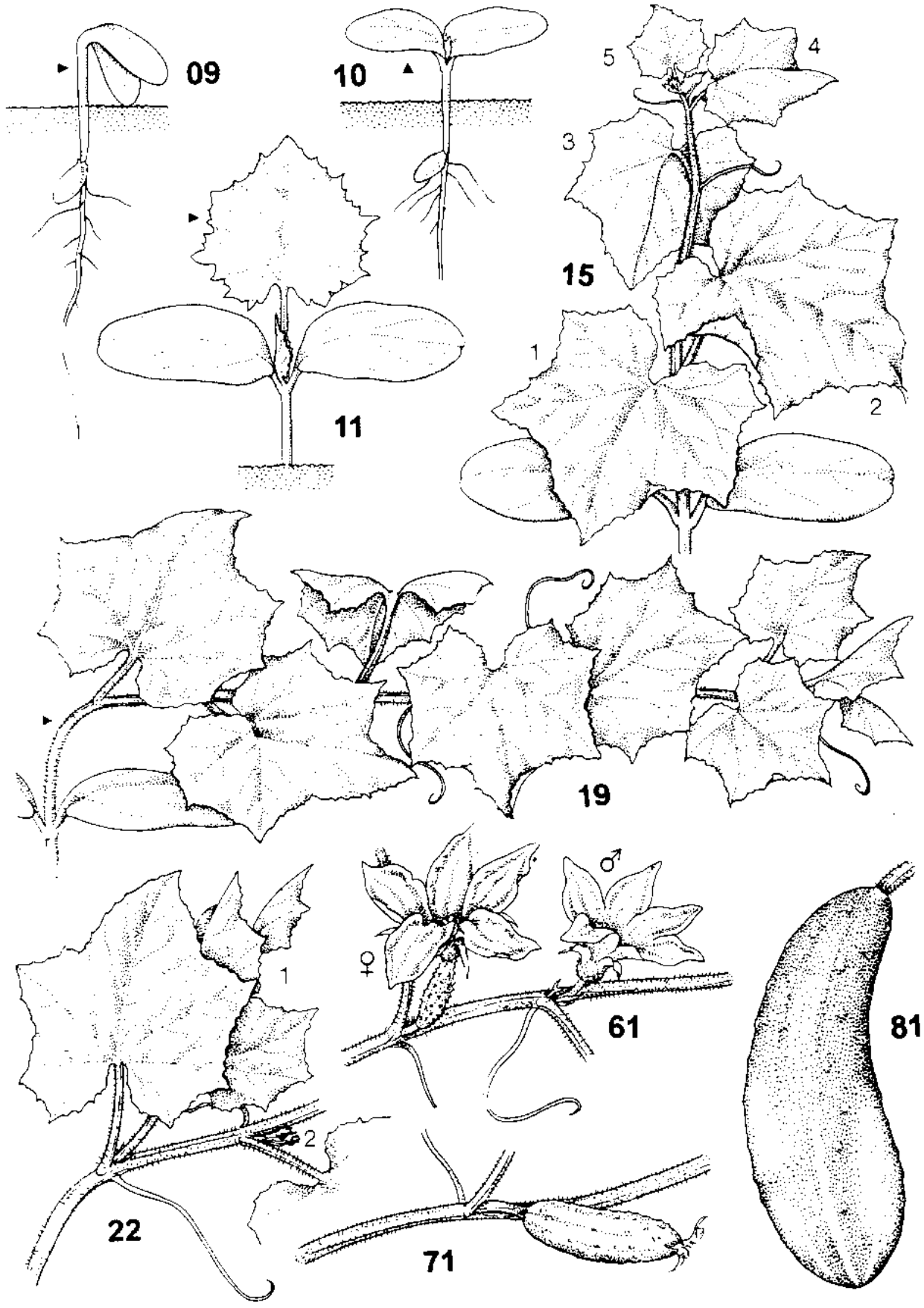
Code		Description
2- and 3digit		
Principal growth stage 5: Inflorescence emergence		
51	501	First flower initial with elongated ovary visible on main stem
52	502	2nd flower initial with elongated ovary visible on main stem
53	503	3rd flower initial with elongated ovary visible on main stem
5 .	50 .	Stages continuous till . . .
59	509	9 or more flower initials with elongated ovary already visible on main stem
–	510	10 or more flower initials with elongated ovary already visible on main stem
–	51 .	Stages continuous till . . .
–	519	19 ore more flower initials with elongated ovary already visible on main stem
–	521	First flower initial visible on a secondary side shoot
–	531	First flower initial visible on a tertiary side shoot
2 -and 3digit		
Principal growth stage 6: Flowering		
61	601	First flower open on main stem
62	602	2nd flower open on main stem
63	603	3rd flower open on main stem
6 .	60 .	Stages continuous till . . .
69	609	9th flower open on main stem or 9 flowers on main stem already open
–	610	10th flower open on main stem or 10 flowers on main stem already open
–	61 .	Stages continuous till . . .
–	619	19th flower open on man stem ore more than 19 flowers on main stem already open
–	621	First flower on secondary side shoot open
–	631	First flower on tertiary side shoot open

Cucurbits Feller et al., 1995 b

Phenological growth stages and BBCH-identification keys of cucurbits

Code		Description
2- and 3digit		
Principal growth stage 7: Development of fruit		
71	701	First fruit on main stem has reached typical size and form
72	702	2nd fruit on main stem has reached typical size and form
73	703	3rd fruit on main stem has reached typical size and form
7 .	70 .	Stages continuous till . . .
79	709	9 or more fruits on main stem has reached typical size and form
–	721	First fruit on a secondary side shoot has reached typical size and form
–	731	First fruit on a tertiary side shoot has reached typical size and form
2 -and 3digit		
Principal growth stage 8: Ripening of fruit and seed		
81	801	10% of fruits show typical fully ripe colour
82	802	20% of fruits show typical fully ripe colour
83	803	30% of fruits show typical fully ripe colour
84	804	40% of fruits show typical fully ripe colour
85	805	50% of fruits show typical fully ripe colour
86	806	60% of fruits show typical fully ripe colour
87	807	70% of fruits show typical fully ripe colour
88	808	80% of fruits show typical fully ripe colour
89	809	Fully ripe: fruits have typical fully ripe colour
2- and 3digit		
Principal growth stage 9: Senescence		
97	907	Plants dead
99	909	Harvested product (seeds)

Cucurbits



Solanaceous fruits Feller et al., 1995 b

Phenological growth stages and BBCH-identification keys of solanaceous fruits
(Tomato = *Lycopersicon esculentum* Mill., aubergine = *Solanum melongena* L., paprika = *Capsicum annuum* L)

Code		Description
2 -and 3digit		
Principal growth stage 0: Germination		
00	000	Dry seeds
01	001	Beginning of seed imbibition
03	003	Seed imbibition complete
05	005	Radicle emerged from seed
07	007	Hypocotyl with cotyledons breaking through seed coat
09	009	Emergence: coryledons break through soil surface
2- and 3digit		
Principal growth stage 1: Leaf development		
10	100	Cotyledons completely unfolded
11	101	First true leaf on main shoot fully unfolded
12	102	2nd leaf on main shoot unfolded
13	103	3rd leaf on main shoot unfolded
1 .	10 .	Stages continuous till . . .
19	109	9 or more leaves on main shoot unfolded
2 -and 3digit		
Principal growth stage 2: Formation of side shoots[1]		
21	201	First primary apical side shoot visible
22	202	2nd primary apical side shoot visible
2 .	20 .	Stages continuous till . . .
29	209	9 or more apical primary side shoots visible
–	221	First secondary apical side shoot visible
–	22 .	Stages continuous till . . .
–	229	9th secondary apical side shoot visible
–	231	First tertiary apical side shoot visible
–	23 .	Stages continuous till . . .
–	2NX	Xth apical side shoot of the Nth order visible

[1] For tomatoes with determinate stem growth, paprika and aubergines. In tomatoes with indeterminate stem growth and only one sympodial branch at the corresponding axis, the apical side shoot formation occurs concurrently with the emergence of the inflorescence (Principal growth stage 5), so that the coding within principal growth stage 2 is not necessary

Solanaceous fruits Feller et al., 1995 b

Phenological growth stages and BBCH-identification keys of solanaceous fruits

Code		Description
2- and 3digit		
Principal growth stage 5: Inflorescence emergence		
51	501	First inflorescence visible (first bud erect)[2] First flower bud visible[3]
52	502	2nd inflorescence visible (first bud erect)[2] 2nd flower bud visible[3]
53	503	3th inflorescence visible (first bud erect)[2] 3th flower bud visible[3]
5 .	50 .	Stages continuous till . . .
59	509	9 or more inflorescences visible (2digit), 9th inflorescence visible(first bud erect) (3digit)[2] 9 or more flower buds already visible (2digit), 9th flower bud visible (3digit)[3]
–	510	10th inflorescence visible (first bud erect)[2] 10th flower bud visible[3]
–	51 .	Stages continuous till . . .
–	519	19th inflorescence visible (first bud erect)[2] 19th flower bud visible[3]
2 -and 3digit		
Principal growth stage 6: Flowering		
61	601	First inflorescence: first flower open[2] First flower open[3]
62	602	2nd inflorescence: first flower open[2] 2nd flower open[3]
63	603	3rd inflorescence: first flower open[2] 3rd flower open[3]
6 .	60 .	Stages continuous till . . .
69	609	9 or more inflorescences with open flowers (2digit) 9th inflorescence: first flower open (3digit)[2] 9 or more flowers already open (2digit) 9th flower open (3digit)[3]
–	610	10th inflorescence: first flower open[2] 10th flower open[3]
–	61 .	Stages continuous till . . .
–	619	19th inflorescence: first flower open[2] 19th flower open[3]

[2] For tomato
[3] For paprika and aubergine

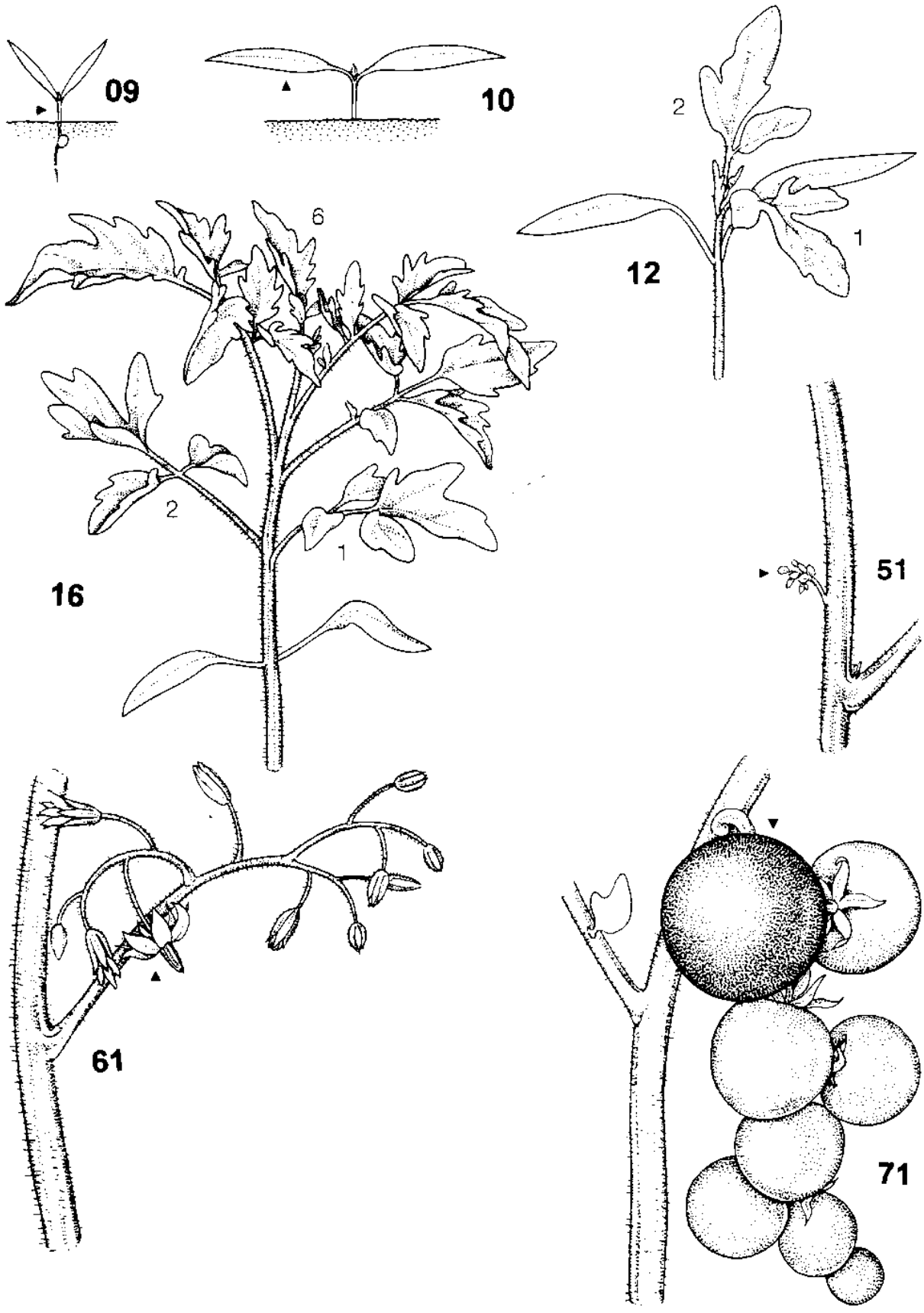
Solanaceous fruits Feller et al., 1995 b

Phenological growth stages and BBCH-identification keys of solanaceous fruits

Code		Description
2- and 3digit		
Principal growth stage 7: Development of fruit		
71	701	First fruit cluster: first fruit has reached typical size[2] First fruit has reached typical size and form[3]
72	702	2nd fruit cluster: first fruit has reached typical size[2] 2nd fruit has reached typical size and form[3]
73	703	3rd fruit cluster: first fruit has reached typical size[2] 3rd fruit has reached typical size and form[3]
7 .	70 .	Stages continuous till . . .
79	709	9 or more fruit clusters with fruits of typical size (2digit) 9th fruit cluster:first fruit has reached typical size (3digit)[2] 9 or more fruits have reached typical size and form (2digit) 9th fruit has reached typical size and form(3digit)[3]
–	710	10th fruit cluster: first fruit has reached typical form and size[2] 10th fruit has reached typical form and size[3]
–	71 .	Stages continuous till . . . 19th fruit has reached typical form and size[3]
–	719	19th fruit cluster: first fruit has reached typical form and size[2]
2 -and 3digit		
Principal growth stage 8: Ripening of fruit and seed		
81	801	10% of fruits show typical fully ripe colour
82	802	20% of fruits show typical fully ripe colour
83	803	30% of fruits show typical fully ripe colour
84	804	40% of fruits show typical fully ripe colour
85	805	50% of fruits show typical fully ripe colour
86	806	60% of fruits show typical fully ripe colour
87	807	70% of fruits show typical fully ripe colour
88	808	80% of fruits show typical fully ripe colour
89	809	Fully ripe: fruits have typical fully ripe colour[3]
2- and 3digit		
Principal growth stage 9: Senescence		
97	907	Plants dead
99	909	Harvested product

[2] For tomato
[3] For paprika and aubergine

Solanaceous fruits



Pea Weber and Bleiholder, 1990; Feller et al., 1995 b

Phenological growth stages and BBCH-identification keys of pea
(Pisum sativum L.)

Code	Description
Principal growth stage 0: Germination	
00	Dry seed
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from seed
07	Shoot breaking through seed coat
08	Shoot growing towards soil surface; hypocotyl arch visible
09	Emergence: shoot breaks through soil surface ("cracking stage")
Principal growth stage 1: Leaf development	
10	Pair of scale leaves visible
11	First true leaf (with stipules) unfolded or first tendril developed
12	2 leaves (with stipules) unfolded or 2 tendrils developed
13	3 leaves (with stipules) unfolded or 3 tendrils developed
1 .	Stages continuous till . . .
19	9 or more leaves (with stipules) unfolded or 9 or more tendrils developed
Principal growth stage 3: Stem elongation (Main shoot)	
30	Beginning of stem elongation
31	1 visibly extended internode[1]
32	2 visibly extended internodes[1]
33	3 visibly extended internodes[1]
3 .	Stages continuous till . . .
39	9 or more visibly extended internodes[1]
Principal growth stage 5: Inflorescence emergence	
51	First flower buds visible outside leaves
55	First separated flower buds visible outside leaves but still closed
59	First petals visible, flowers still closed

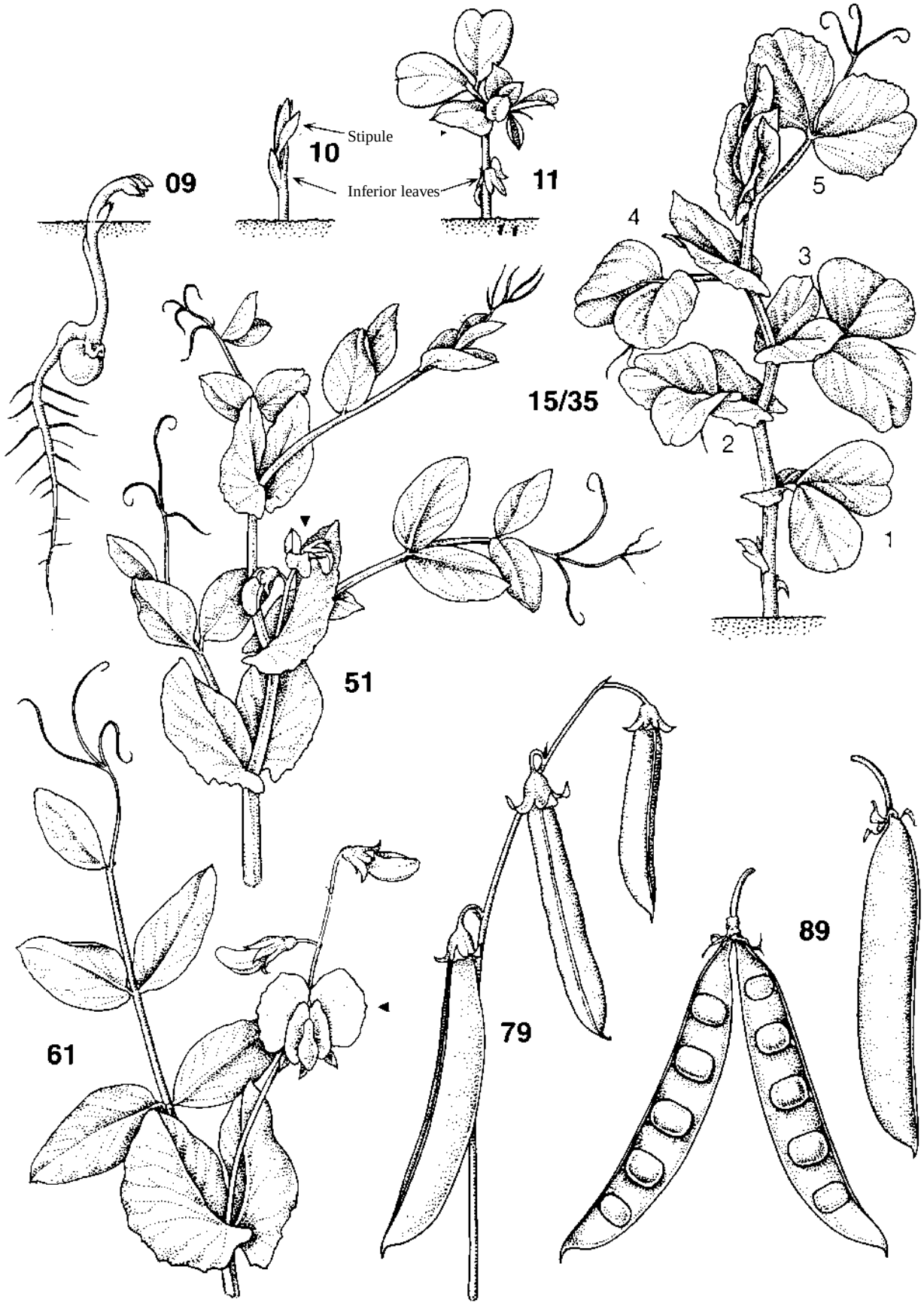
[1] The first internode extends from the scale leaf node to the first true leaf node

Pea Weber and Bleiholder, 1990; Feller et al., 1995 b

Phenological growth stages and BBCH-identification keys of pea

Code	Description
Principal growth stage 6: Flowering	
60	First flowers open (sporadically within the population)
61	Beginning of flowering: 10% of flowers open
62	20% of flowers open
63	30% of flowers open
64	40% of flowers open
65	Full flowering: 50% of flowers open
67	Flowering declining
69	End of flowering
Principal growth stage 7: Development of fruit	
71	10% of pods have reached typical length; juice exudes if pressed
72	20% of pods have reached typical length; juice exudes if pressed
73	30% of pods have reached typical length; juice exudes if pressed.Tenderometer value: 80 TE
74	40% of pods have reached typical length; juice exudes if pressed.Tenderometer value: 95 TE
75	50% of pods have reached typical length; juice exudes if pressed.Tenderometer value: 105 TE
76	60% of pods have reached typical length; juice exudes if pressed.Tenderometer value: 115 TE
77	70% of pods have reached typical length. Tenderometer value: 130 TE
79	Pods have reached typical size (green ripe); peas fully formed
Principal growth stage 8: Ripening of fruit and seed	
81	10% of pods ripe, seeds final colour, dry and hard
82	20% of pods ripe, seeds final colour, dry and hard
83	30% of pods ripe, seeds final colour, dry and hard
84	40% of pods ripe, seeds final colour, dry and hard
85	50% of pods ripe, seeds final colour, dry and hard
86	60% of pods ripe, seeds final colour, dry and hard
87	70% of pods ripe, seeds final colour, dry and hard
88	80% of pods ripe, seeds final colour, dry and hard
89	Fully ripe: all pods dry and brown. Seeds dry and hard (dry ripe)
Principal growth stage 9: Senescence	
97	Plants dead and dry
99	Harvested product

Pea



Bean Feller et al., 1995 b

Phenological growth stages and BBCH-identification keys of Bean
(*Phaseolus vulgaris* var. *nanus* L.),

Code	Description
Principal growth stage 0: Germination	
00	Dry seed
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from seed
07	Hypocotyl with cotyledons breaking through seed coat
08	Hypocotyl reaches the soil surface; hypocotyl arch visible
09	Emergence: hypocotyl with cotyledons break through soil surface (“cracking stage”)
Principal growth stage 1: Leaf development	
10	Cotyledons completely unfolded
12	2 full leaves (first leaf pair unfolded)
13	3rd true leaf (first trifoliate leaf) unfolded
1 .	Stages continuous till . . .
19	9 or more leaves (2 full leaves, 7 or more trifoliate) unfolded
Principal growth stage 2: Formation of side shoots	
21	First side shoot visible
22	2nd side shoot visible
23	3rd side shoot visible
2 .	Stages continuous till . . .
29	9 or more side shoots visible
Principal growth stage 5: Inflorescence emergence	
51	First flower buds visible
55	First flower buds enlarged
59	First petals visible, flowers still closed

Bean Feller et al., 1995 b

Phenological growth stages and BBCH-identification keys of Bean

Code	Description
	Principal growth stage 6: Flowering
60	First flowers open (sporadically within the population)
61	Beginning of flowering: 10% of flowers open[1] Beginning of flowering[2]
62	20% of flowers open[1]
63	30% of flowers open[1]
64	40% of flowers open[1]
65	Full flowering: 50% of flowers open[1] Main flowering period[2]
67	Flowering finishing: majority of petals fallen or dry[1]
69	End of flowering: first pods visible[1]
	Principal growth stage 7: Development of fruit
71	10% of pods have reached typical length[1] Beginning of pot development[2]
72	20% of pods have reached typical length[1]
73	30% of pods have reached typical length[1]
74	40% of pods have reached typical length[1]
75	50% of pods have reached typical length, beans beginning to fill out[1] Main pod development period[2]
76	60% of pods have reached typical length[1]
77	70% of pods have reached typical length, pods still break cleanly[1]
78	80% of pods have reached typical length[1]
79	Pods: individual beans easily visible[1]
	Principal growth stage 8: Ripening of fruit and seed
81	10% of pods ripe (beans hard)[1] Seeds beginning to mature[2]
82	20% of pods ripe (beans hard)[1]
83	30% of pods ripe (beans hard)[1]
84	40% of pods ripe (beans hard)[1]
85	50% of pods ripe (beans hard)[1] Main period of ripening[2]
86	60% of pods ripe (beans hard)[1]
87	70% of pods ripe (beans hard)[1]
88	80% of pods ripe (beans hard)[1]
89	Fully ripe: pods ripe (beans hard)[1]

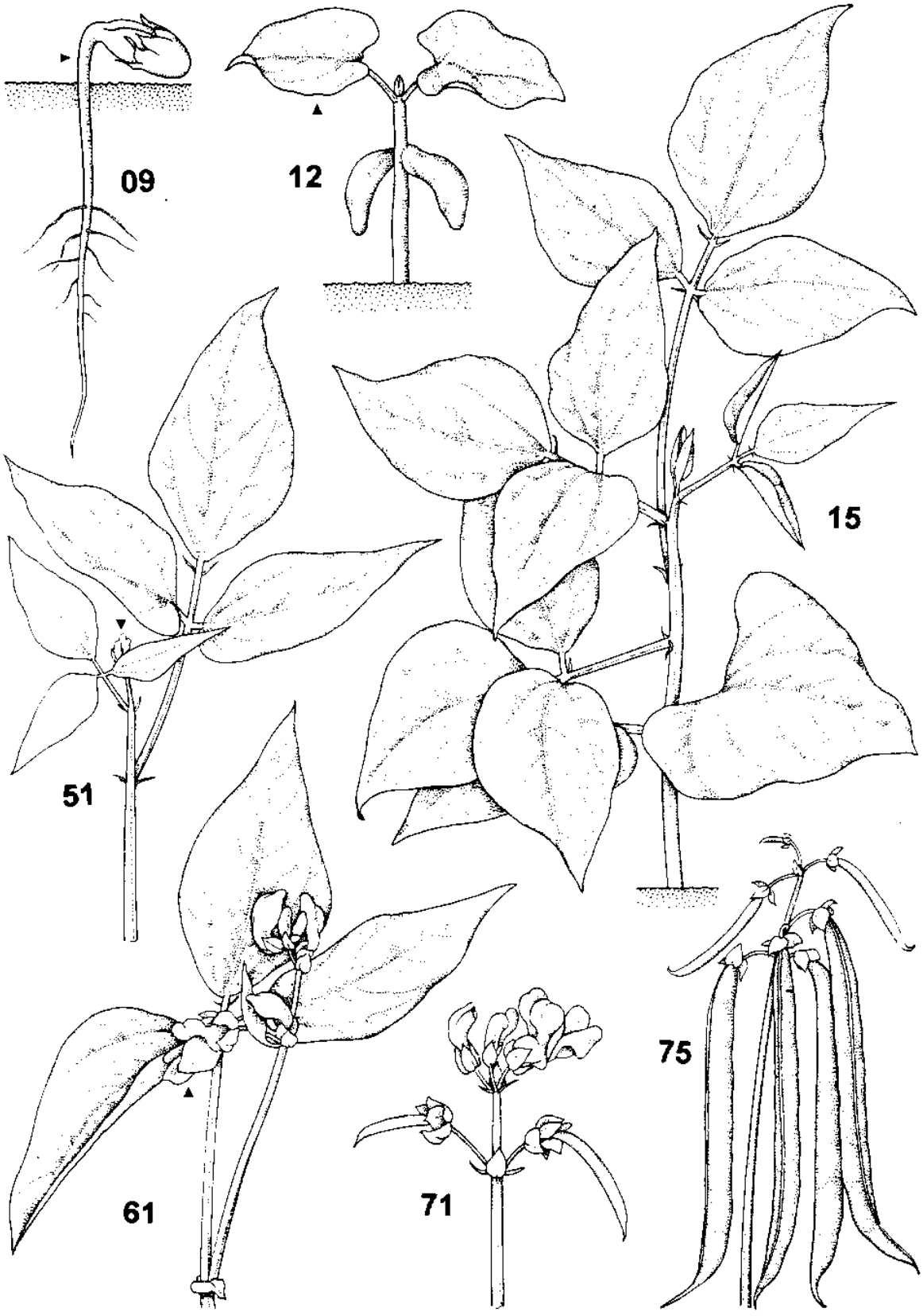
1 For varieties with limited flowering period
2 For varieties in which the flowering period is not limited

Bean Feller et al., 1995 b

Phenological growth stages and BBCH-identification keys of Bean

Code	Description
Principal growth stage 9: Senescence	
97	Plants dead
99	Harvested product

Bean



Weed species Hess et al., 1997

Phenological growth stages and BBCH-identification keys of weed species

D = **D**icotyledons,
G = **G**ramineae,
M = **M**onocotyledons,
P = **P**erennial plants,
V = Development from vegetative parts or propagated organs.

No code letter is used if the description applies to all groups of plants.

Code		Description
Principal growth stage 0: Germination, sprouting, bud development		
00		Dry seed
	V	Perennating or reproductive organs during the resting period (tuber, rhizome, bulb, stolon)
	P	Winter dormancy or resting period
01		Beginning of seed imbibition
	P, V	Beginning of bud swelling
03		Seed imbibition complete
	P, V	End of bud swelling
05		Radicle (root) emerged from seed
	V	Perennating or reproductive organs forming roots
06		Elongation of radicle, formation of root hairs and/or lateral roots
07	G	Coleoptile emerged from caryopsis
	D, M	Hypocotyl with cotyledons or shoot breaking through seed coat
	P, V	Beginning of sprouting or bud breaking
08	D	Hypocotyl with cotyledons or shoot growing towards soil surface
	V	Shoot growing towards soil surface
09	G	Emergence: Coleoptile breaks through soil surface
	D, M	Emergence: Cotyledons break through soil surface (except hypogeal germination);
	V	Emergence: Shoot/Leaf breaks through soil surface
	P	Buds show green tips
Principal growth stage 1: Leaf development (main shoot)		
10	G, M	First true leaf emerged from coleoptile
	D	Cotyledons completely unfolded
	P	First leaves separated
11		First true leaf, leaf pair or whorl unfolded
	P	First leaves unfolded
12		2 true leaves, leaf pairs or whorls unfolded
13		3 true leaves, leaf pairs or whorls unfolded
1 .		Stages continuous till ...
19		9 or more true leaves, leaf pairs or whorls unfolded

Weed species Hess et al., 1997

Phenological growth stages and BBCH-identification keys of weed species

Code		Description
Principal growth stage 2: Formation of side shoots / tillering		
21		First side shoot visible
	G	First tiller visible
22		2 side shoots visible
	G	2 tillers visible
23		3 side shoots visible
	G	3 tillers visible
2 .		Stages continuous till ...
29		9 or more side shoots visible
	G	9 or more tillers visible
Principal growth stage 3: Stem elongation / shoot development (main shoot)		
30		Beginning of stem elongation
	G	Beginning of shooting
31		1 visibly extended internode
	G	1 node stage
32		2 visibly extended internode;
	G	2 node stage
33		3 visibly extended internode
	G	3 node stage
3 .		Stages continuous till ...
39		9 or more visibly extended internodes
	G	9 or more nodes
Principal growth stage 4: vegetative propagation / booting (main shoot)		
40	V	Vegetative reproductive organs begin to develop (rhizomes, stolons, tubers, runners, bulbs)
41	G	Flag leaf sheath extending
42	V	First young plant visible
43	G	Flag leaf sheath just visibly swollen (mid-boot)
45	G	Flag leaf sheath swollen (late-boot)
47	G	Flag leaf sheath opening
49	V	Constant new development of young plants; vegetative reproductive organs reach final size
	G	First awns visible

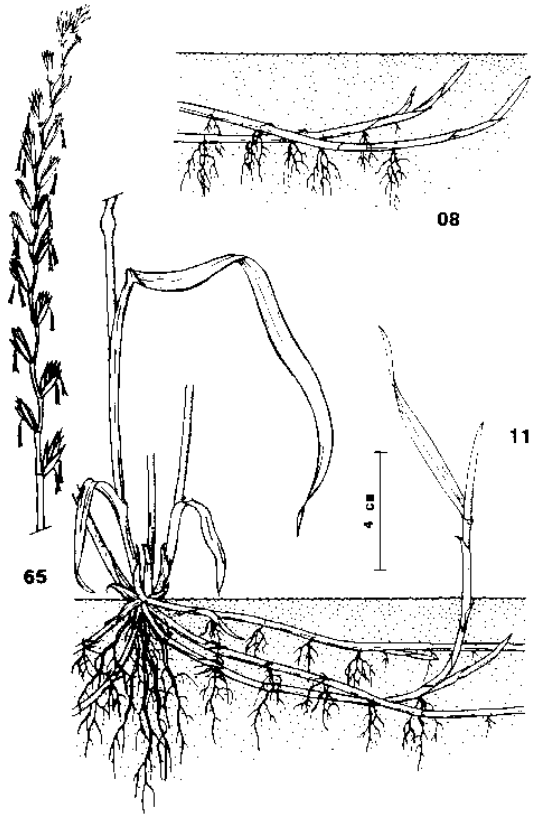
Weed species Hess et al., 1997

Phenological growth stages and BBCH-identification keys of weed species

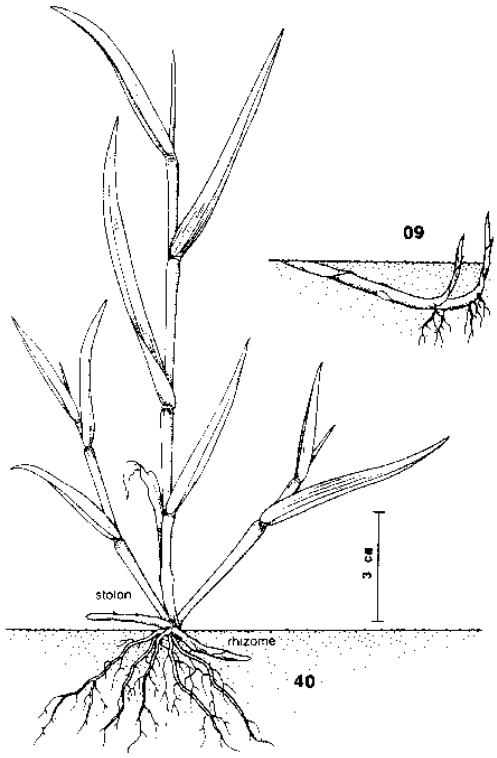
Code		Description
Principal growth stage 5: Inflorescence emergence (main shoot) / heading		
51		Inflorescence or flower buds visible
	G	Beginning of heading
55		First individual flowers visible (still closed)
	G	Half of inflorescence emerged (middle of heading)
59		First flower petals visible (in petalled forms)
	G	Inflorescence fully emerged (end of heading)
Principal growth stage 6: Flowering (main shoot)		
60		First flowers open (sporadically)
61		Beginning of flowering: 10% of flowers open
63		30% of flowers open
65		Full flowering: 50% of flowers open, first petals may be fallen
67		Flowering finishing: majority of petals fallen or dry
69		End of flowering: fruit set visible
Principal growth stage 7: Development of fruit		
71		Fruits begin to develop
	G	Caryopsis watery ripe
79		Nearly all fruits have reached final size normal for the species and location
Principal growth stage 8: Ripening or maturity of fruit and seed		
81		Beginning of ripening or fruit coloration
89		Fully ripe
Principal growth stage 9: Senescence, beginning of dormancy		
97		End of leaf fall, plants or above ground parts dead or dormant;
	P, V	Plant resting or dormant

Weed species

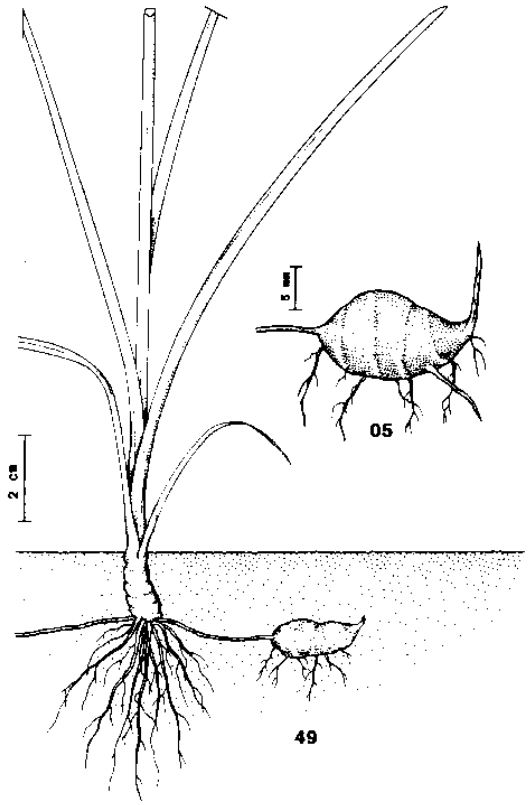
Agropyron repens (L.) P. Beauv.



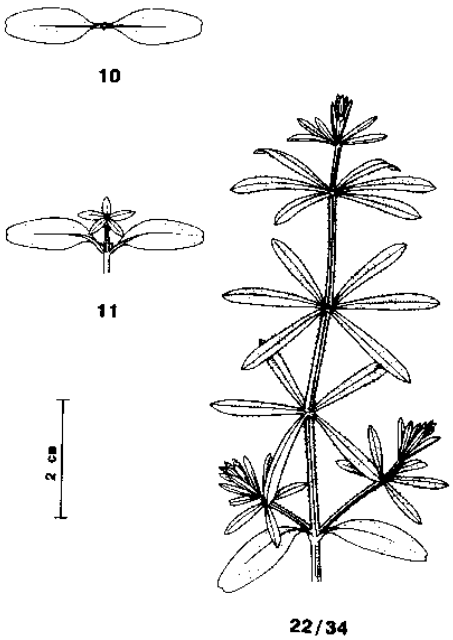
Cynodon dactylon (L.) Pers.



Cyperus rotundus L.

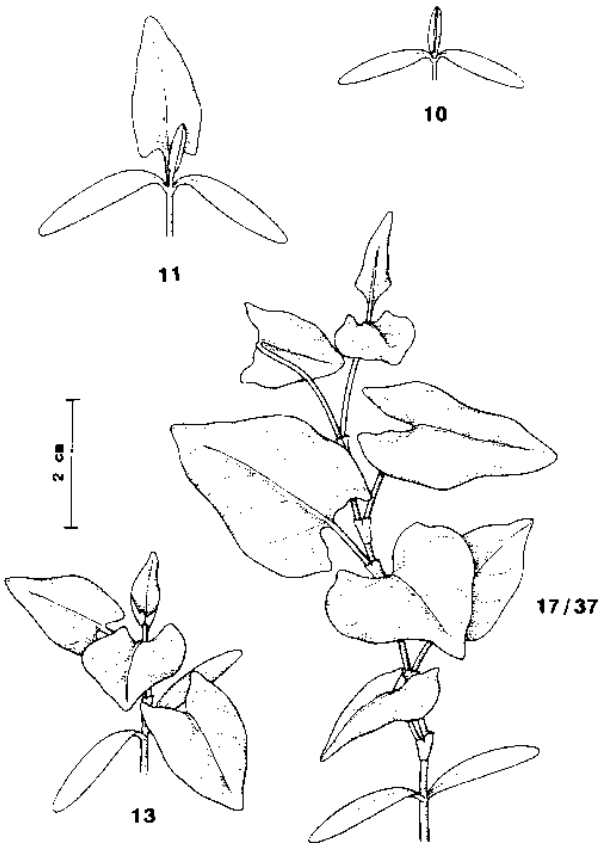


Galium aparine L.

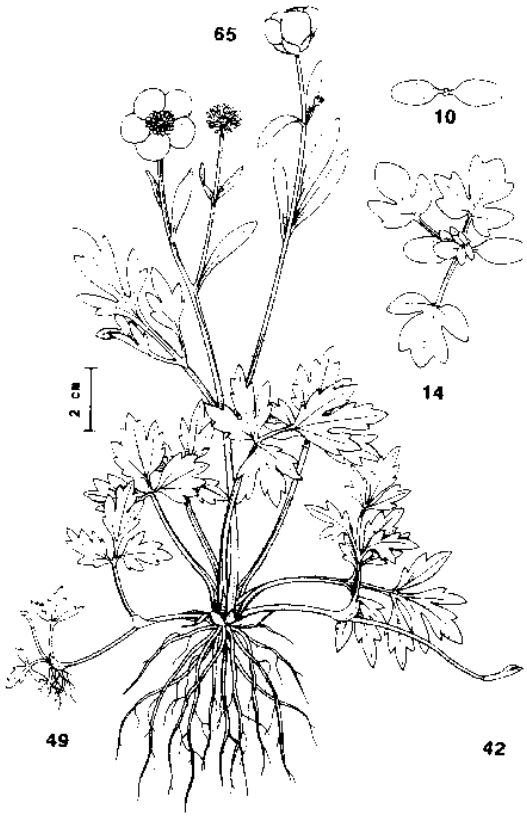


Weed species

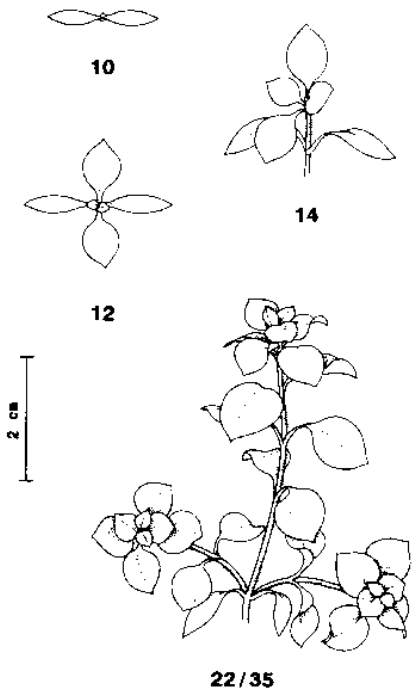
Polygonum convolvulus L.



Ranunculus repens L.

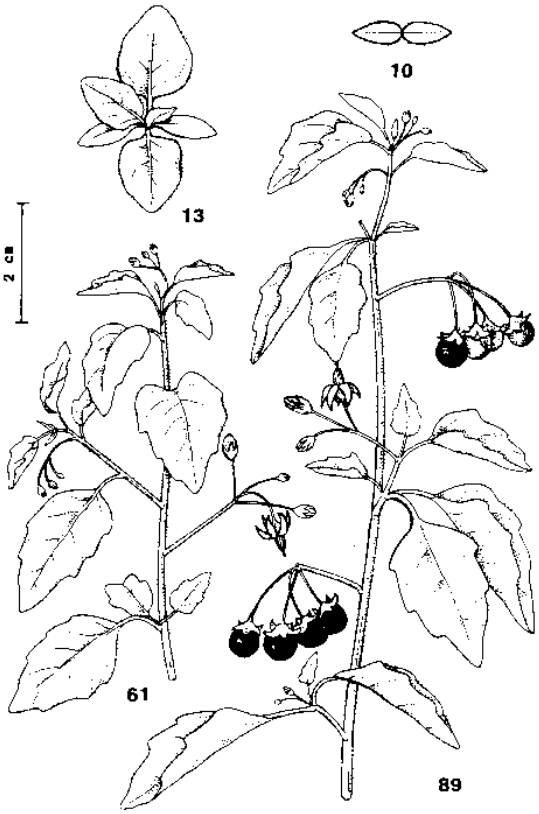


Stellaria media (L.) Vill.

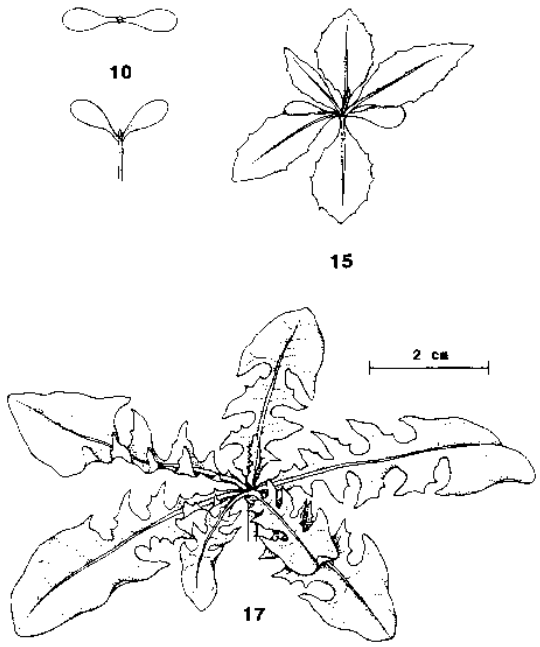


Weed species

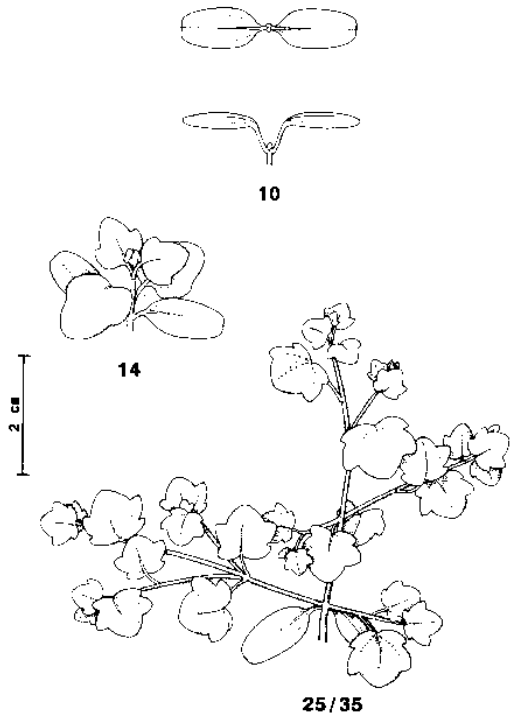
Solanum nigrum L



Taraxacum officinale Wiggers



Veronica hederifolia L.



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