Weed Research, 1997, Volume 37, 433–441

Use of the extended BBCH scale – general for the descriptions of the growth stages of mono- and dicotyledonous weed species

M. HESS*, G. BARRALIS†, H. BLEIHOLDER‡, L. BUHR§, TH. EGGERS¶, H. HACK** AND R. STAUSS††

**Hoechst Schering AgrEvo GmbH, Marktforschung, Werk Höchst K 607, D-65926 Frankfurt am Main;* †*Institut National de la Recherche Agronomique (INRA), Laboratoire de Malherbologie, BV 1540, F-21034 Dijon Cédex;* ‡*BASF AG, Landwirtschaftliche Versuchsstation, Postfach 120, D-67114 Limburgerhof;* §*Biologische Bundesanstalt für Land- und Forstwirtschaft (BBA), Institut für Ökotoxikologie im Pflanzenschutz, Stahnsdorfer Damm 81, D-14532 Kleinmachnow;* ¶*Biologische Bundesanstalt für Land- und Forstwirtschaft (BBA), Institut für Unkrautforschung, Messeweg 11–12, D-38104 Braunschweig;* ***Industrieverband Agrar (IVA), Theodor-Storm-Weg 2, D-51519 Odenthal;* ††*Ministerium für ländliche Räume, Landwirtschaft und Tourismus des Landes Schleswig-Holstein, Düsternbrooker Weg 104, D-24105 Kiel (formerly Ciba AG, Basle)*

Received 13 June 1997
Revised version accepted 24 July 1997

Summary

The extended BBCH scale is a system for a uniform coding of phenologically similar growth stages of all mono- and dicotyledonous plant species, based on the well-known cereal code of Zadoks *et al.* (1974). The BBCH key is a decimal system, with 10 principal growth stages and up to 10 secondary ones, starting with seed germination/sprouting of perennials, progressing through leaf production and extension growth to flowering and senescence. Therefore, it can also be a suitable tool to define the growth stages of different weed species. To encourage further use of the BBCH scale in weed research, definitions of the codes have been more closely adapted to weeds. Possible problems are discussed and guidelines for correct use are given.

The abbreviation BBCH derives from the institutions that jointly developed this scale: BBA, Biologische Bundesanstalt für Land- und Forstwirtschaft (German Federal Biological Research Centre for Agriculture and Forestry); BSA, Bundessortenamt (German Federal Variety Authority); CHemical Industry, Industrieverband Agrar, IVA (German Association of Manufacturers of Agrochemical Products).

Introduction

Whatever method of weed control is used, it is very important not only to know exactly which weeds are present but also to be able to describe in detail the growth stages of the different species. The success of the various weed control methods depends to a large extent on the growth stages of the weeds at application time.

In recent years, it has become a relatively simple matter to recognize weeds, thanks to a number of excellent books that also include detailed illustrations of early weed growth stages (Schwär *et al.*, 1970; Anon., 1971; Holm *et al.*, 1977; Holzner, 1981; Hanf, 1982; Jauzein & Montégut, 1983; Auld & Medd, 1987; Cremer *et al.*, 1991; Kissmann & Groth, 1991, 1992, 1995; Jauzein, 1995). The medium of CD-ROM has also been introduced to recognize weeds (Barralis *et al.*, 1992). A simple weed nomenclature suitable for computer use has been made possible by the Bayer Code (Anon., 1992), which has greatly simplified worldwide communication.

Nevertheless, there is still no uniform system for describing weed growth stages. The first attempt to standardize the descriptions of weed growth stages in Germany was made in response to Merkblatt No. 27, issued by the BBA (Anon., 1964). This was an alphabetical system consisting of definitions of eight *principal* growth stages, each of which could be extended numerically. A revised version of this (Anon., 1986) attempted to cater for the increasing importance of data processing by introducing a decimal system that allowed for subdivisions into principal and secondary growth stages. But, ultimately, no attempt was made to follow the suggestion of Eggers & Heidler (1985, 1986), i.e. to form a link-up with crop species, all of which have the same codes for the same growth stages.

The result of this was that stage 25, for example, meant three leaves or leaf pairs for weeds, four leaf pairs for sugar beet, seven leaves for maize and five tillers for cereals. Each of the specific scales made sense for the crop species in question and for dicotyledonous weeds, but was somewhat confusing and unsystematic for practical users confronted simultaneously with several different crop species and weed groups.

Attempts have been made in the UK to develop a simple code for weeds that could be easily handled by practicians. Lutman & Tucker (1987) drew up a set of 15 growth stage descriptions. The result was not so much a scale as a list of the most important weed growth stages as an aid to weed control decisions. Some of these stages are defined simply in terms of weed size, as in the BBA scale (Anon., 1986). Lawson & Read (1992) suggested that the Zadoks scale for cereals (Zadoks *et al.*, 1974) might possibly be used for annual grass weeds and finally recommended this with only minor restrictions.

Bleiholder *et al.* (1990), Lancashire *et al.* (1991) and Hack *et al.* (1992) proposed a uniform decimal code that can be used for both crop plants and weeds. This universal scale, also known in abbreviated form as the 'BBCH scale', is based mainly on the description given by Zadoks *et al.* (1974). After special scales had been introduced for a number of crop plants to allow for specific features of different species, the use of the BBCH scales has now been widely adopted.

The BBCH scale is also highly suitable for use with weeds:

- it permits definite identification of the correct time for control measures;
- it is suitable for all areas of scientific and practice-oriented weed research;
- it facilitates international communication and electronic data exchange between scientific institutions, commercial firms and registration authorities;
- it simplifies the work for users, because it follows the same principles for crop plants and weeds.

The aim of this article is to show that the 'Extended BBCH Scale – General' also has particular advantages for weed research.

Structure of the scale for weeds

The entire developmental cycle of the plants is subdivided into 10 clearly recognizable and distinguishable longer term developmental stages. These principal growth stages are described using numbers from 0 to 9 in ascending order (Table 1).

The principal growth stages alone are not suitable for exact determination of application or evaluation dates as they always describe time spans in the course of development of a plant. Secondary stages are used if it is necessary to obtain precise information on points of time in plant development. This is particularly important for deciding application times during early weed development.

The secondary stages are the characteristic short developmental steps of a particular plant species and take place in a particular order during the corresponding principal stage (Table 2). They also have a coding based on the numbers 0–9. The two numbers together, i.e. one for the principal stage and one for the secondary stage, make up the two-digit code. Where two or more principal stages run parallel

Table 1. Principal growth stages for describing the phenological development of mono- and dicotyledonous plants

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	Vegetative propagation/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

Table 2. BBCH scale for describing the phenological growth stages of weed species

0		**Germination/sprouting**
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, M	Hypocotyl with cotyledons or shoot 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)
	V	Emergence: shoot/leaf breaks through soil surface
	P	Buds show green tips
1		**Leaf development (main shoot)**
10	G, M	First true leaf emerged from coleoptile
	D	Cotyledons completely unfolded
	P	First leaves spread/separated
11		First true leaf or whorl unfolded
	P	First leaves unfolded
12		Two true leaves or whorls unfolded
13		Three true leaves or whorls unfolded; stages continuous until ...
19		Nine or more leaves or whorls unfolded
2		**Formation of side shoots/tillering**
21		First side shoot visible
	G	First tiller visible
22		Two side shoots visible
	G	Two tillers visible
23		Three side shoots visible
	G	Three tillers visible; stages continuous until ...
29		Nine or more side shoots visible
	G	Nine or more tillers visible
3		**Stem elongation/shoot development (main shoot)**
30		Beginning of stem elongation
	G	Beginning of shooting
31		One visibly extended internode
	G	One-node stage
32		Two visibly extended internodes
	G	Two-node stage
33		Three visibly extended internodes
	G	Three-node stage; stages continuous until ...
39		Nine or more visibly extended internodes
	G	Nine or more nodes
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
5		**Inflorescence emergence (main shoot)/heading**
51		Inflorescence or flower buds visible
	G	Beginning of heading

Table 2. (*Contd.*)

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)
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 have fallen
67		Flowering finishing: majority of petals fallen or dry
69		End of flowering: fruit set visible
7		**Development of fruit**
71		Fruits begin to develop
	G	Caryopsis watery ripe
79		Nearly all fruits have reached the final size normal for the species and location
8		**Ripening or maturity of fruit and seed**
81		Beginning of ripening or fruit coloration
89		Fully ripe
9		**Senescence or beginning of dormancy**
97		Plant dead
	P, V	Plant resting or dormant

* For key see end of section entitled Structure of the scale for weeds

on one and the same plant (for example leaf development, side-shoot formation, stem elongation), the corresponding two-digit codes may be given separately with an oblique stroke in between (for example *Galium aparine* L. 22/34; Fig. 1).

For a uniform coding that covers the maximum number of plant species, it was necessary to look primarily to phenological criteria rather than to homologous or analogous stages. Thus, for example, germination of plants from true seed as well as sprouting from buds were classed in the same principal growth stage (stage 0), even although they are completely different biological processes.

The extended BBCH scale and its descriptions are based on the actual characteristic features of the individual plants. In weed science, the scale is used for determining the stage of development of a whole plant stand. The description should cover the majority of the plants. As there are very many different plant species, their course of development will often not always follow the same pattern and certain stages may even be missing. In the case of weeds, the principal growth stages need not proceed in the strict sequence implied by the ascending order of the numbers but may even run partly or completely parallel. As a general rule, the more advanced stage of development, or the most important in each particular case, should be chosen.

If the same weed is present at very different developmental stages, it is advisable to assess the plants separately by stage. Examples of this are plants of the same species that occur simultaneously but have emerged either in spring or in the preceding autumn, for example *G. aparine* 11 and *G. aparine* 34 or *Agropyron repens* (L.) P. Beauv. 11 and *Agropyron repens* 65 (Fig. 1).

When the BBCH scale for weeds (Table 2) was being prepared, allowance had to be made – as in the 'Extended BBCH Scale General' – for considerable developmental differences between the various plant groups. To deal with this difficulty, several definitions were provided for the same stage in all cases where a uniform text could not be drawn up. The plant group to which a particular definition applies can be seen from the abbreviated prefix in Table 2. If a description is applicable to all plant groups, no prefix is written.

D, dicotyledons
G, gramineae
M, monocotyledons
P, perennial plants

V, development from vegetative perennating or reproductive organs.

The BBCH scale can also be used to describe the developmental stages of weeds that cannot be assigned to any of these five plant groups because of their particular type of vegetative development. For *Equisetum* spp., for example, the principal stages 1–4 can be used along the same lines as those for the monocotyledons and dicotyledons. In contrast, the vegetative development of Filices, for example *Pteridium aquilinum* (L.) Kühn, cannot be described in terms of leaf development per plant, side-shoot formation or stem elongation, and the BBCH scale cannot be used for this purpose. For describing the specific generative reproduction systems of Pteridophyta species the BBCH scale is unsuitable.

Description of the scale for weeds

Principal stage 0: germination/sprouting

Code 00 here describes the resting period. It applies to seeds and also to the dormant buds of perennial plants. In addition to annual seeded plants, the weed scale will also include vegetatively-reproducing perennial species forming either rhizomes [*Agropyron repens*, *Sorghum halepense* (L.) Pers.], adventive buds on an extended root system [*Convolvulus arvensis* L., *Cirsium arvense* (L.) Scop.] or tubers (*Cyperus* spp.) and woody plants.

Within the principal growth stage 0, dormancy 00 is followed by germination (for seeds) and sprouting (for vegetative perennating organs and woody plants). Stage 09 is emergence (Fig. 1).

Principal growth stage 1: leaf development (main shoot)

Principal growth stage 1 comprises the subdivisions of leaf development on the main shoot. In the case of weeds, this is certainly one of the most important developmental steps for determining suitable application times. Most species are still sufficiently small and sensitive for adequate control. Most species can be precisely identified at this stage and in most cases will not yet have caused irreversible damage to the crop plants.

For the 'Extended BBCH Scale – General' (Hack *et al.*, 1992), it is a general principle that the nodes are the decisive basis for leaf counting. This means that the absolute number of true leaves at the same secondary growth stage may differ from one plant species to another, for example alternate or opposite phyllotaxy. If, however, the general BBCH scale was followed to its logical conclusion, stage 12 of *Polygonum aviculare* L. would mean two true leaves. In the case of *Lamium amplexicaule* L., stage 12 would mean two leaf pairs with four true leaves. The problem with plants that form rosettes is that it is not possible to count the nodes. For weeds, therefore, it is recommended that only the number of true leaves or whorls should be used for determining the growth stage. This corresponds to the procedure used for *Beta* spp. (Meier *et al.*, 1993).

For monocotyledons, stage 10 means that the first true leaf has emerged from the coleoptile, for dicotyledons that the cotyledons are fully developed and for trees and shrubs that the first leaves have spread apart. If it is of importance to distinguish whether a young plant is growing from a seed or a rhizome bud, a separate note should be taken. The separate secondary stages within the principal growth stage proceed from 11 to 19 for one true leaf or whorls up to nine or more. It is generally unnecessary to count any further as the plants have usually already reached more advanced growth stages.

Principal growth stage 2: formation of side shoots/tillering

In the case of dicotyledons with upright stem growth, the easiest form of identification is formation of side shoots (*Atriplex patula* L.; Fig. 1), with attention being paid only to the side shoots formed on the main stem. For species with low-lying or creeping stems it is often difficult to identify the main stem at all [*Stellaria media* (L.) Vill., *Veronica* spp. (Fig. 1)]. The correct stage is then identified by counting the number of side shoots and subtracting one, which is taken to be the main shoot. For grasses, the tillers are counted.

Principal growth stage 3: stem elongation (main shoot)/shoot development (main shoot)

In the 'Extended BBCH Scale – General', stem elongation is given as a percentage of the maxi-

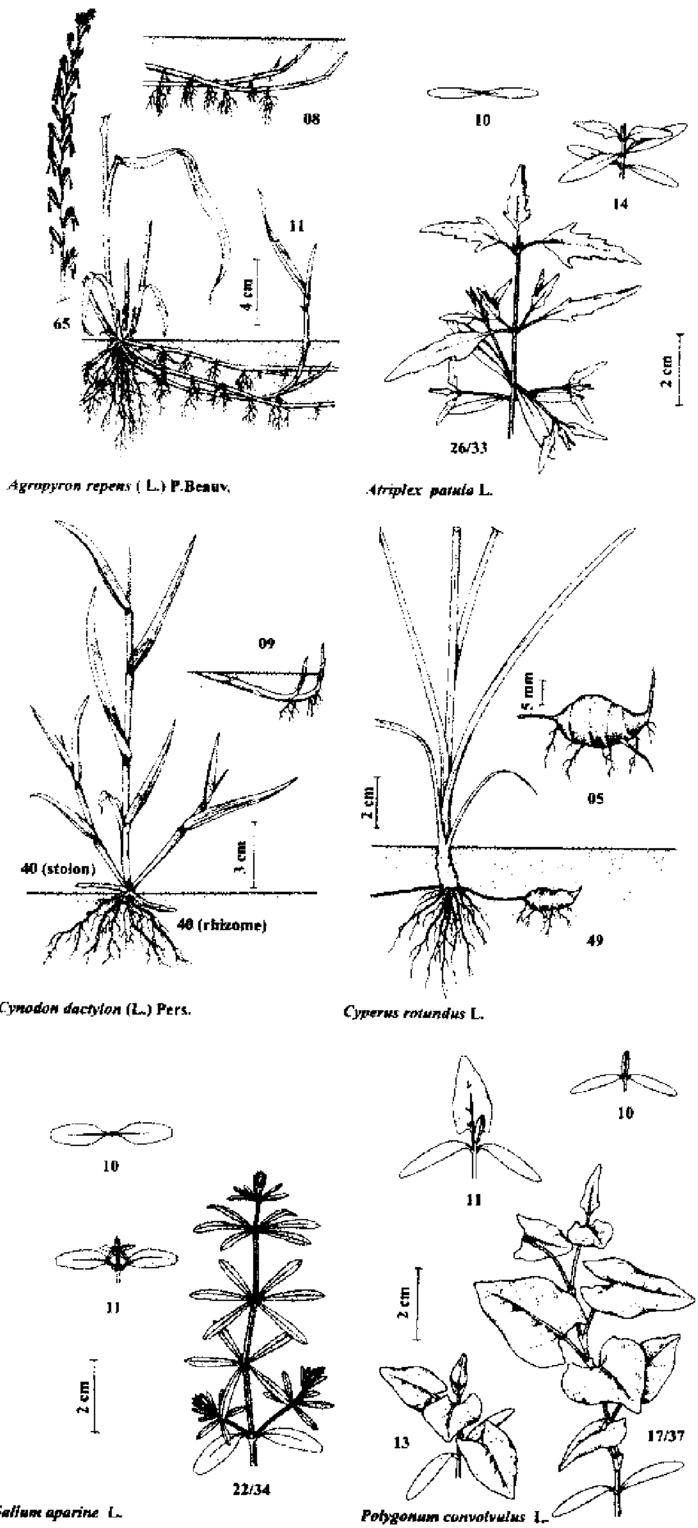

Fig. 1. BBCH growth stages of selected weed species.

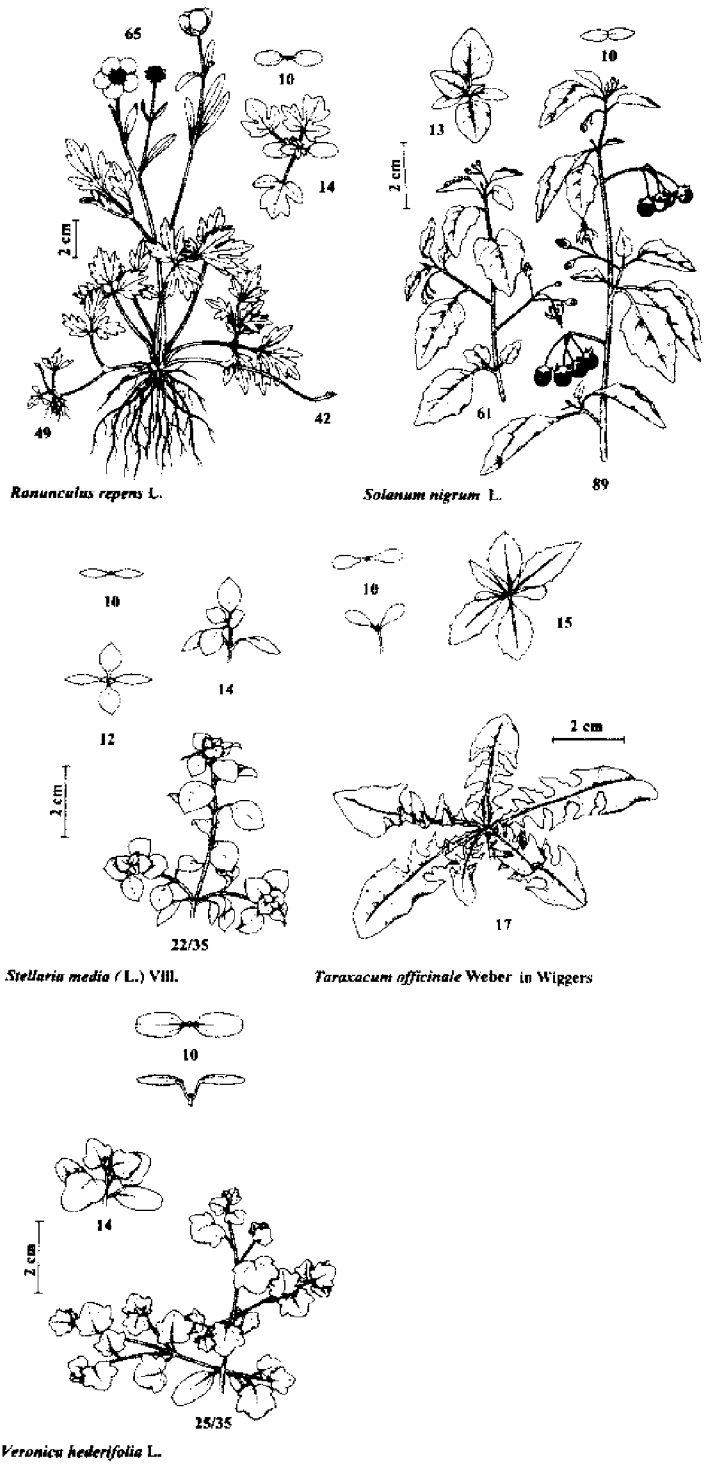

Fig. 1. BBCH growth stages of selected weed species.

mum typical plant height for the crop species. An experienced inspector will be able to predict the height of a crop with a fair degree of certainty, but this is not possible with weeds. There would be no practical value in defining stage 35 for *G. aparine* as the stage in which 50% of the expected stem elongation has been reached.

In any case, it would be impossible for absolute plant heights to be given in a universal scale intended for very many species under a great variety of growth conditions. Sizes given as important have been known to range considerably even for relatively similar climatic zones such as the British Isles and Germany (Anon., 1986; Lutman & Tucker, 1987).

If absolute plant heights are required, they should be noted separately in addition to the stage code: no good purpose would be served by incorporating them in a scale intended for worldwide use.

In vascular plants a great part of the body arises by repetition of a single structure unit called the shoot, which consists of a stem, which grows more or less indefinitely, bearing leaves that ordinarily grow to a standard size. The part of a stem to which one or more leaves are attached is called a node, and the piece between two successive nodes is an internode. The stem elongation is described by the number of nodes or internodes.

Stem elongation needs to be recorded only in situations when unusual elongation without branching occurs under special growth conditions. Examples of this might be the growth of *G. aparine* or *C. arvensis* under strong competitive pressure in standing cereals in which a single unbranched shoot shows strong upward growth.

When Gramineae are considered as weeds, their secondary growth stages are defined by the numbers of nodes. Thus, the higher stages 37 and 39 do not follow the special code for cereals (Witzenberger *et al.*, 1989; Lancashire *et al.*, 1991).

Principal growth stage 4: vegetative propagation/booting

The vegetative reproduction of perennial plants constitutes principal growth stage 4.

The formation of vegetative reproductive organs – such as rhizomes, stolons, tubers, runners, bulbs – and growth of new daughter plants as offshoots [*Ranunculus repens* L. (Fig. 1) and *Eichhornia crassipes* (Mart.) Solms] are distinguished.

Only two secondary growth stages are used to describe the development of vegetative reproductive organs, i.e. 40 (vegetative reproductive organs begin to develop) and 49 (vegetative reproductive organs reach final size). Most vegetative reproductive organs grow underground, which makes it difficult to give exact details. It is also difficult to provide general definitions of possible intermediate stages for the different types of vegetative reproductive organs. Even for crop plants with harvested vegetative plant parts, such as carrots, potatoes or various vegetable species, principal growth stage 4 is subdivided into only a few secondary stages (Meier *et al.*, 1993; Hack *et al.*, 1993; Feller *et al.*, 1995).

As soon as new plants have formed from the vegetative reproductive organs, the descriptions given are those for independent plants, starting with principal growth stage 0 (germination/sprouting).

Direct vegetative reproduction, in which no vegetative storage or perennating organs are formed, is also described with only two secondary growth stages. Stage 42 is the time when the first young plants become visible, and 49 is defined as constant new development of young plants.

This description applies not only to a number of dry-land plants able to reproduce in a similar way to that of the strawberry (for example *Ranunculus repens*) but is also particularly suitable for water plants (*E. crassipes* (Mart.) Solms, *Pistia stratiotes* L., *Dichondra repens* J. R. & G. Forst).

For grasses, this principal growth stage is used to described booting.

Principal growth stages 5–9: generative reproduction

The following principal growth stages are used largely for the generative development of flowers, development of fruit, ripening of fruits and seeds, and finally the senescence of annual plants. Where the description is insufficient, use can be made of the 'Extended BBCH Scale – General'.

The more advanced growth stages are in general of no further importance for weed control purposes, but some perennial weeds are best controlled at or near flowering, for example

C. arvense. Under certain circumstances, advanced growth stages may be of interest for describing the further development of uncontrolled, or inadequately controlled, weeds. The question as to whether incompletely controlled weeds may still form seeds is becoming increasingly important. For weed control trials it is also necessary to be able to record the growth stages of weeds in the untreated control plots.

Conclusion

The objective in devising this BBCH scale is to bring more order to the use of growth stage scales of weeds. It has been necessary to make some compromises in the design of the scale: including all the subtle details of the growth of every weed in one scale would produce an impossibly cumbersome system. Thus, something must be left out. Those who work on weed vegetation in several crops may find the small loss of detail an acceptable price to pay for a single scale that is uniform, simple to remember and capable of being used in computer systems.

Acknowledgement

Thanks go to Mr Ernst Haiwaß from Nossen, Germany, for the creation of drawings of the growth stages of selected weed species.

References

ANONYMOUS (1964) *Entwicklungsstadien der grasartigen und zweikeimblättrigen Kulturpflanzen und Unkräuter*. Biologische Bundesanstalt für Land- und Forstwirtschaft, Berlin and Braunschweig, Merkblatt No. **27**, 1. Auflage.

ANONYMOUS (1971) Common Weeds of the United States. United States Department of Agriculture, New York.

ANONYMOUS (1986) *Entwicklungsstadien zweikeimblättriger Unkräuter*. Biologische Bundesanstalt für Land- und Forstwirtschaft, Braunschweig, Merkblatt No. 27/9.

ANONYMOUS (1992) *Important Crops of the World and their Weeds*, 2nd edn. Business Group Crop Protection, Bayer AG, Leverkusen.

AULD BA & MEDD RW (1987) *Weeds - an Illustrated Botanical Guide to the Weeds of Australia*. Inkata Press, Melbourne.

BARRALIS G, GASQUEZ J, LONCHAMP JP, JAUZEIN P, KERGUELEN M, LE CLERCH J *et al.* (1992) *Malherb logiciel d'aide à la reconnaissance des mauvaises herbes*. CD-ROM edited by INRA and CNERTA.

BLEIHOLDER H, WEBER E, VAN DEN BOOM T *et al.* (1990) A new, uniform decimal code for growth stages of crops and weeds. *Proceedings 1990 Brighton Crop Protection Conference - Pests & Diseases*, Brighton, 667–72.

CREMER J, PARTZSCH M, ZIMMERMANN G, SCHWÄR Ch & GOLTZ H (1991) *Acker- und Gartenwildkräuter*. Deutscher Landwirtschaftsverlag, Berlin.

EGGERS Th & HEIDLER G (1985) Entwicklungsstadien von Unkräutern. *Nachrichtenblatt des Deutschen Pflanzenschutzdienstes* **37**, 71–6.

EGGERS Th & HEIDLER G (1986) Weed growth stages. *Plant Research and Development*, Tübingen **24**, 57–69.

FELLER C, BLEIHOLDER H, BUHR L *et al.* (1995) Phänologische Entwicklungsstadien von Gemüse. I. Zwiebel-, Wurzel-, Knollen- und Blattgemüse. Codierung und Beschreibung nach der erweiterten BBCH-Skala - mit Abbildungen. *Nachrichtenblatt des Deutschen Pflanzenschutzdienstes* **47**, 193–206.

HACK H, BLEIHOLDER H, BUHR L *et al.* (1992) Einheitliche Codierung der phänologischen Entwicklungsstadien mono- und dikotyler Pflanzen. - Erweiterte BBCH-Skala, Allgemein -. *Nachrichtenblatt des Deutschen Pflanzenschutzdienstes* **44**, 265–70.

HACK H, GALL H, KLEMKE Th *et al.* (1993) Phänologische Entwicklungsstadien der Kartoffel (*Solanum tuberosum* L.) Codierung und Beschreibung nach der erweiterten BBCH-Skala, mit Abbildungen. *Nachrichtenblatt des Deutschen Pflanzenschutzdienstes* **45**, 11–19.

HANF M (1982) *Ackerunkräuter Europas mit ihren Keimlingen und Samen*. Klambt-Druck, Speyer.

HOLM LG, PLUCKNETT DL, PANCHO JV & HERBERGER JP (1977) *The World's Worst Weeds - Distribution and Biology*. University Press of Hawaii, Honolulu.

HOLZNER W (1981) *Ackerunkräuter. Bestimmung, Verbreitung, Biologie und Ökologie*. Stocker, Graz.

JAUZEIN P (1995) *Flore des Champs Cultivés*. INRA and Sopra.

JAUZEIN P & MONTEGUT J (1983) *Graminées Nuisibles en Agriculture*. Aubervilliers, France.

KISSMANN KG & GROTH D (1991, 1992, 1995) *Plantas Infestantes e Nocivas*. BASF SA, Sao Paulo.

LANCASHIRE PD, BLEIHOLDER H, VAN DEN BOOM T *et al.* (1991) A uniform decimal code for growth stages of crops and weeds. *Annals of Applied Biology* **119**, 561–601.

LAWSON HM & READ MA (1992) The description of the growth stages of annual grass weeds. *Annals of Applied Biology* **121**, 211–14.

LUTMAN PJW & TUCKER GG (1987) Standard descriptions of growth stages of annual dicotyledonous weeds. *Annals of Applied Biology* **110**, 683–7.

MEIER U, BACHMANN L, BUHTZ E *et al.* (1993) Phänologische Entwicklungsstadien der Beta-Rüben (*Beta vulgaris* L. ssp.). Codierung und Beschreibung nach der erweiterten BBCH-Skala mit Abbildungen. *Nachrichtenblatt des Deutschen Pflanzenschutzdienstes* **45**, 37–41.

SCHWÄR Ch, FEYERABEND G & GOLTZ H (1970) 100 *Wichtige Ackerunkräuter*. VEB Gustav Fischer, Jena.

WITZENBERGER A, VAN DEN BOOM T & HACK H (1989) Erläuterungen zum BBCH-Dezimal-Code für die Entwicklungsstadien des Getreides, mit Abbildungen. *Gesunde Pflanzen* **41**, 384–8.

ZADOKS JC, CHANG TT & KONZAK CF (1974) A decimal code for the growth stages of cereals. *Weed Research* **14**, 415–21.