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A REFERENCE SYSTEM FOR COTTON PLANT DEVELOPMENT

Celso Jamil Marur and Onaur Ruano
Áreas de Ecofisiologia e de Proteção de Plantas
Instituto Agronomico do Parana
Londrina, PR – Brazil

Abstract

This work presents a reference system that easily identifies the stages of development of upland cotton (*Gossypium hirsutum* L.) independently of genotype, age of plant, or environmental influence. These stages are basically characterized as functions of the phenological phases, namely, vegetative (V), formation of flower buds (B), flowering (F) and boll cracking (C). Between seedling emergence up to the time when the first true leaf has expanded to 2.5 cm, measured on the mid-vein, the stage of development is designated V_0. Between the upper limit of V_0 until the mid-vein of the second true leaf measures 2.5 cm is V_1. Applying the same criterion successively, the plant will advance through the stages V_2, V_3, V_4, V_5, etc. When the first flower bud (square) is visible, the stage designation changes to B_1. Successively, determined by when the first square of a new fruiting branch (sympodium) is visible, the stage will become B_n. When the square at the first fruiting position of the first sympodium reaches anthesis (open flower), the stage designation becomes F_1. Any subsequent developmental stage, determined by the occurrence of an open flower on the first fruiting node of sympodium *n*, will be F_n. When the boll at the first fruiting position of the first sympodium begins to dehisce (cracked boll), the stage of development is designated C_1. Successive stages will be C_n, where *n* is the number of the sympodium with a newly cracked boll at the first fruiting position. To determine the predominant stage of development of plants in an experiment, observations should be made on a minimum of 20 plants randomly distributed throughout the plot. In the case of a production field, each hectare of the crop should be sampled by the same method. Some specific situations are also discussed, such as the characterization of a stunted plant or the occurrence of a regrowth. A nomenclature of vegetative branches is also suggested.

Introduction

The major objective of modern agriculture is to attain maximal high quality yields with minimum impact on the environment. Independently of the production system used during cultivation, better results can be achieved when management practices are applied at the most appropriate crop development stage. Thus, an understanding of how a plant grows as well as the precise characterization of its different developmental stages are crucial for farmers and technicians to apply crop management practices efficiently.

The upland cotton plant (*Gossypium hirsutum* L. r. *latifolium* Hutch), because of its indeterminate growth habit, has one of the most complex plant morphologies of cultivated species (Mauney, 1984). Its growth and development are described in detail by numerous authors, most notably Mauney (1984), Munro (1987), and Oosterhuis & Jernstedt (1999).

When a cultural practice or observation is taken in a cotton crop or experimental area, it's common to say that this cultural practice or observation occurred "so many" days after emergence. Characterization of a phase of crop development based on a chronological parameter results in important variations from the real phenological stage in comparisons between environments and/or years because development is strongly influenced by environment, mainly in respect to its temperature requirements (Bolonhezi et al., 2001).

Those working in cotton research, or in the management of cotton fields, recognize the need for a detailed scale with which it is possible to identify, with ease and precision, the stage at which an event occurs, or for application of a specific cultural practice. One of the most recent scales was presented by Elsner *et al.* (1979). They divided the stages of growth into only two groups, namely vegetative and reproductive, subdivided into functions of the number of true leaves and of fruiting branches, respectively. One disadvantage of this method is that it ignores the different structures that compose the phenology of a cotton plant. Moreover, the method does not clearly characterize the developmental stages at the time new fruiting branches are no longer formed.

With the aid of a computer, cotton growth and development modeling has gained a strong tool for crop management. However, the differences in life cycle among cultivars do not allow the models to estimate with precision the stage of development under different field conditions. As in-put parameters, information on growth and development is required. The model COTMAN, for example, uses the number of nodes from the top of the plant, and also the date of flower initiation (Bourland et al., 1992). A precise staging method would allow management programs such as COTMAN to incorporate exact phenological parameters into their growth models.

With the objective of providing a more precise characterization of growth of the cotton plant, the present work presents a scale that easily identifies developmental stages of the cotton plant independently of cultivar, age, or environment of the plant.

Proposal for a New Scale

The stages of growth and development are characterized basically as a function of the phenological phases, namely vegetative (V), formation of the flower buds (squaring) (B), open flower (F), and cracked boll (C).

The vegetative period, between emergence of the seedling and before mid-vein of the first true leaf has expanded to 2.5 cm, will be stage V_0 (Figure 1). From the previous limit up to the point that the mid-vein of the second true leaf develops to 2.5 cm, the stage will be V_1. Successively, applying the same criterion, the plant will advance to stages V_2, V_3, V_4, V_5, etc. (Figure 1). In this phase, the true leaf is considered expanded when the mid-vein of the developing leaf is greater than 2.5 cm.

At initiation of the reproduction stage, that is, when the first flower bud (square) is visible, the stage becomes B_1 (Figure 2). When the first square of the third sympodium becomes visible, the plant will be in stage B_3. At this time, the second square of the first sympodium also will be present.

Successively, at the time the first square of a new sympodium is visible, the stage will become B_n (Figure 3). The indication B will no longer be used when the square at the first fruiting position of the first sympodium reaches anthesis (open flower). At this moment, the stage of development will be F_1 (Figure 4).

The stage of development will be F_3 at the opening of the first flower of the third sympodium. Note also that at this phase, an open flower will be located at the second fruiting position of the first sympodium. Successively, at the time the first flower at the first fruiting position of sympodium *n* opens, the stage will be F_n.

Even when square shedding occurs at a first position node of a sympodium, the stage can be determined since other structures that form at the same time can be used as reference. For example, Figure 5 demonstrates stage F_5, normally characterized by an open flower on the 5th sympodium. Although the specific square has abscised, the 2nd fruiting structure of the 3rd sympodium and the 3rd fruiting structure of the 1st sympodium are taken as reference for the definition of stage F_5.

When the 1st boll of the first sympodium begins to dehisce (cracked boll), the stage of development will become C_1 (Figure 6). Successively, the stage will be C_n, based on dehisce of the first boll on sympodium number *n*.

To determine the predominant stages of development of the plants in an experiment, we suggest that observation be made on a minimum of 20 plants selected with some distance between them. In case of a field, use the same procedure for every hectare of area planted. Thus, the final definition of the developmental stage of the population of plants will be given by the stage that occurs with the greatest frequency.

Special Situations

Some specific situations can occur, such as a "stunted" plant, that by chronological age may be, for example, 60 days of age and in stage B_4 (instead F_2). In this case, we recommend that the information on the stage of development be accompanied by the chronological age. Thus, the example designation would be B_4-60 days.

The earliness of a cultivar can be characterized by indicating the chronological age together with initiation of flowering (F_1-46 days), or with termination of the crop (C_5-98 days). In this form, the indication is able to help in the characterization of a late cultivar (F_1-62 days; C_6-165 days).

The active formation of new sympodia after the beginning of flowering can be indicated from the information F_5-B_{15}. Cessation of new sympodial formation (cut-out), caused by the great demand for photosynthate by the bolls can be determined from the expression F_{11}-B_{16}.

In case it is necessary to identify positions on a monopodial branch, we suggest a nomenclature such as $V_3R_2B_3$ to indicate that a monopodial branch was formed at the 3rd true leaf node, two fruiting sympodia were formed, and at the second sympodia were formed 3 bud flowers. In the case of new growth (regrowth), the number two, in Roman numeral, precedes the stage in question. For example, a square formed on the fifth branch of new growth will characterize the stage of development as "II-B_5".

Conclusions

The reference system proposed here aims to standardize the identification of the developmental stages of cotton fields, thus facilitating awareness of the crop and production management decisions.

The scale allows results from different locations to be compared.

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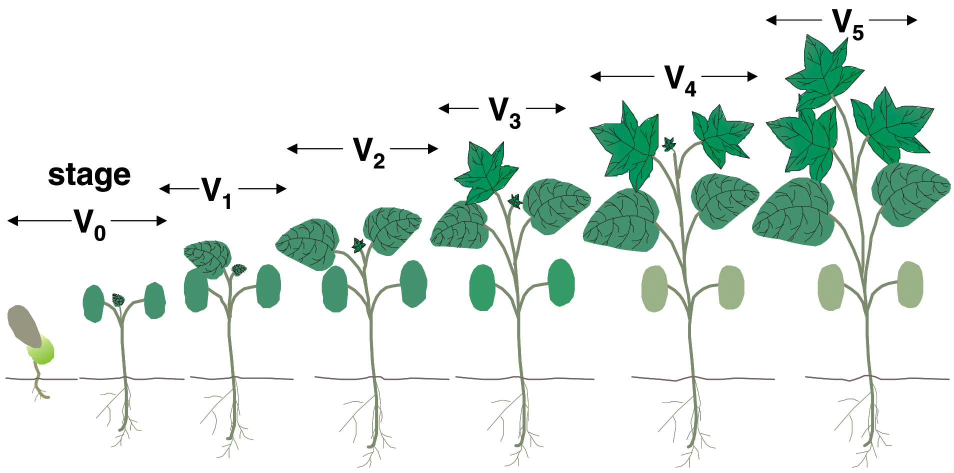

Figure 1. Vegetative stages of the cotton plant – V_0, V_1, V_2, V_3, V_4 and V_5

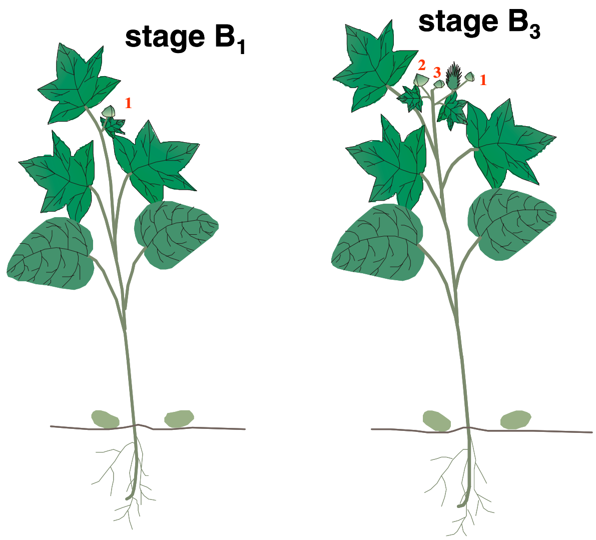

Figure 2. Developmental stages B_1 and B_3

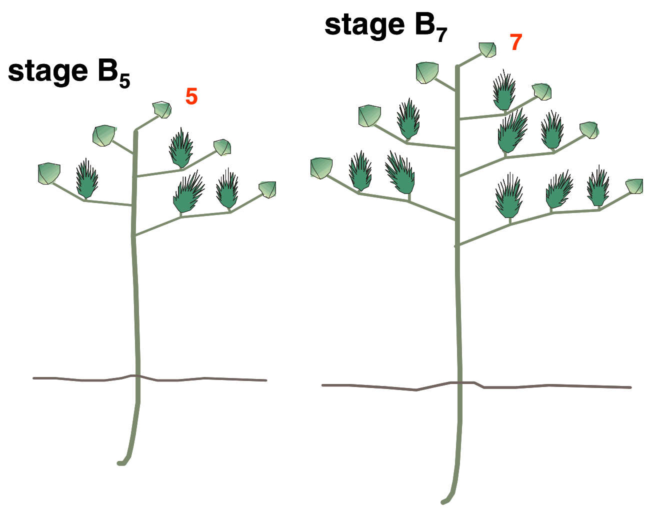

Figure 3. Developmental stages B_5 and B_7

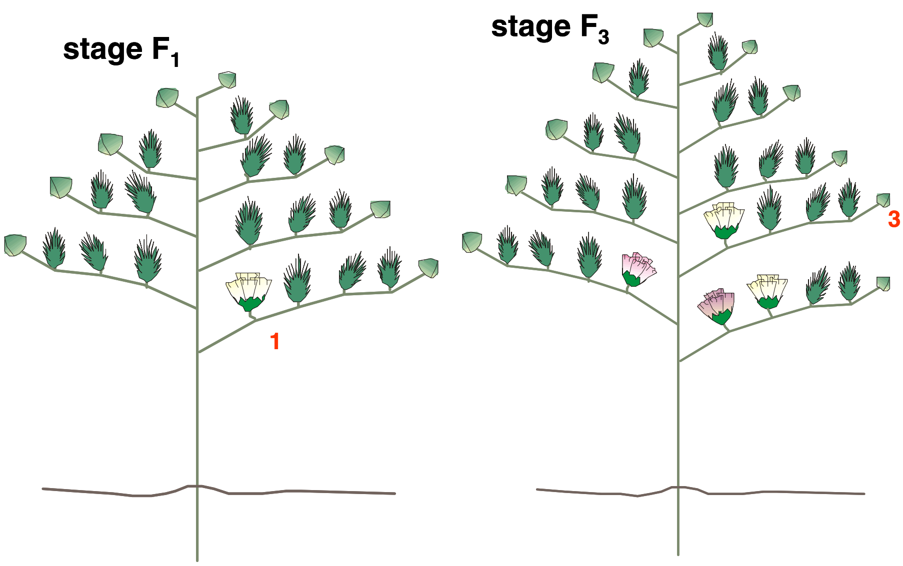

Figure 4. Developmental stages F_1 and F_3

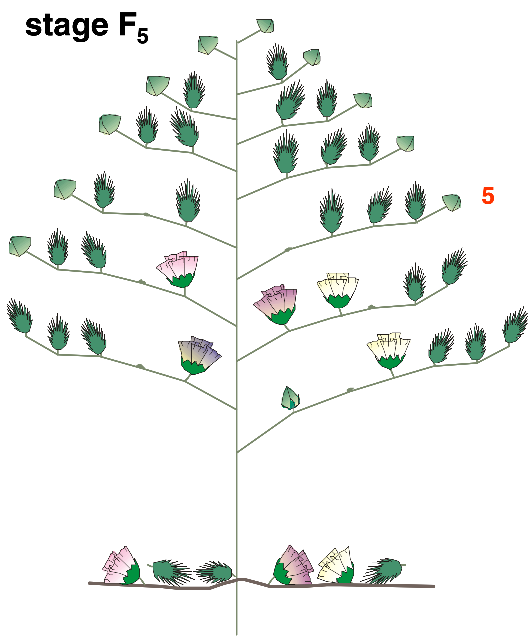

Figure 5. Developmental stage F_5, characterized even with *shedding* occurrence

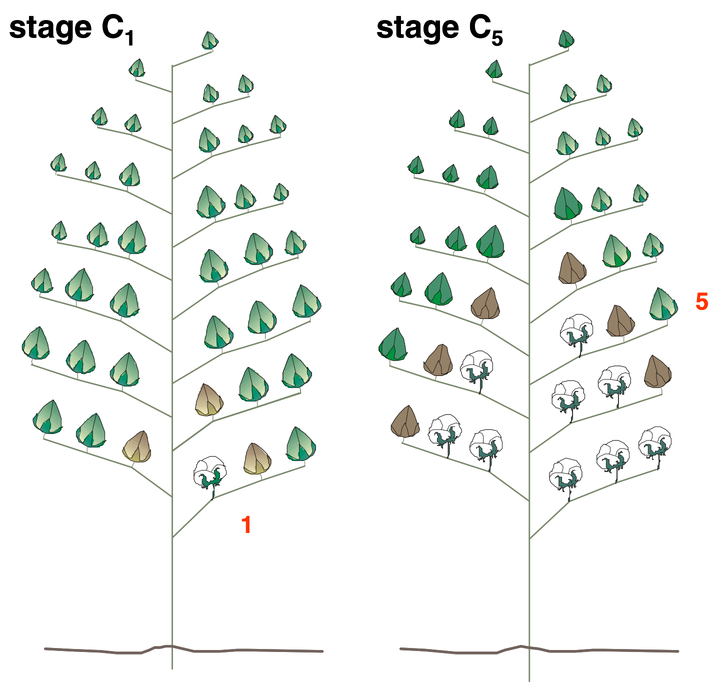

Figure 6. Developmental stages C_1 and C_5