A SCALE OF DEVELOPMENT STAGES OF THE BEAN PLANT PHASEOLUS VULGARIS

A Summary for Consultation

F. Fernández *
P. Gepts

A scale of stages of development of the plant has been useful in regard to several individual grain crops such as corn (Hanway, 1971), sorghum (Vanderlip, 1972), soybeans (Hanway and Thompson, 1971) Such scale serves the following uses :

1) To relate, for research purposes, plant evaluations to a uniform set of descriptors of development stages, rather than to time (days after planting) which may vary with location.
2) To key management practices to development stages as evidenced by visible manifestations of the plant, rather than to age of the plant in days which is influenced by external environmental factors.
3) To help students and young research workers, in beans, to better understand the development of the plant.

For those purposes, a development scale has been proposed by CIAT's Bean Program. This scale is applicable to both determinate and undeterminate bean plant growth types, it consists of ten critical phenological steps comprised into two phases : One vegetative, designated by the letter V, and another reproductive designated by the letter R; either letter preceeding the stage number. In plants of a determinate habit of growth, the visible diferentiation and the physiologic phenomena characterizing the latter part of the vegetative phase and the earlier part of the reproductive phase overlap for a period of time that increases as undertemination of growth habit increases from type I to type IV. Some of the stages may also overlap in most cultivars, thus a convention has been applied as follows : "a phase or stage is superseded by the next as soon as the plant, when individually considered, or fifty percent of the plants of a plot or field, show the manifestation of that next stage". The phenologic observations for the scale were done on plants grown in the experimental fields of CIAT at Palmira, Colombia, at 1000 mts. above sea level and 24°C mean temperature.

A description of the phases and stages follows :

PHASES

Two phases are considered, vegetative and reproductive :

Vegetative Phase From the initiation of germination when the seed swells and the radicle starts to break out until the first floral bud, or floral raceme, appears visible in the plants of determinate or indeterminate growth habit,

* Staff members, International Center of Tropical Agriculture, CIAT, Palmira, Colombia.

respectively. During this phase the meristems of the stem and of the branches form nodes with axilar bud complexes which are succeptible of subsequent vegetative or reproductive development.

Reproductive Phase From the moment the first floral buds or racemes are visible to the naked eye, on through grain formation and physiological maturity. It must be noted that while in cultivars of determinate growth habit vegetative growth ceases upon differentation of the terminal floral bud, in cultivars of undeterminate growth habit, the vegetative growth continues overlaping with the reproductive phase (Figure 1).

DEVELOPMENT STAGES

Ten "stages" have been identified. These are characterized by important physiologic and phenologic events easily recognized by the unaided eye and which occur in all plants regardless of growth habit or external environmental influences; exception occurs with plants that do not flower when lacking the right photoperiodic stimulus.

It must be noted that a "stage" in this scale is not a moment in time nor a differentation phenomena but a stage is a span of time circumscribed by discrete differentiation phenomena at each end. By convention, any stage in the scale ends when the next stage manifests itself in the plant.

In the proposed scale of 0 to 9, five stages have been identified, within the vegetative phase starting with germination. These stages are so designated by successive numbers preceeded by the capital letter V;that is:V0, V1, V2, V3 and V4. Starting with the appearing of floral structures, another five stages have been identified in the reproductive phase and are designated by successive numbers from 5 to 9 preceeded by the letter capital R, that is:R5, R6, R7, R8 and R9.

The authors do not attempt to establish a relation of each stage with time,precisely because a consistent relationship seems to exist accross cultivars at the same location, only for stages V0, V1 and V2 in the vegetative phase and for stage R9 in the reproductive phase (Fig. 2) This relationship, however, is likely to break down when a cultivar is planted at different latitudes or diferent clerations as shown by comparissons of the means of days to flowering of the same twenty varieties at four locations in Colombia.

Location	Mean annual temp. °C	Days to flowering (R6)
Palmira	24	49
Popayan	19	55
La Selva	17	66
Obonuco	13	99

The Scale and Summary Description of Each Stage

Stage V 0, GERMINATION : Starts when the seed is planted,absorbs moisture and translocates nutrients to allow growth of the radicle and the hypocotyl This stage ends when the cotyledons emerge on the surface of the soil.

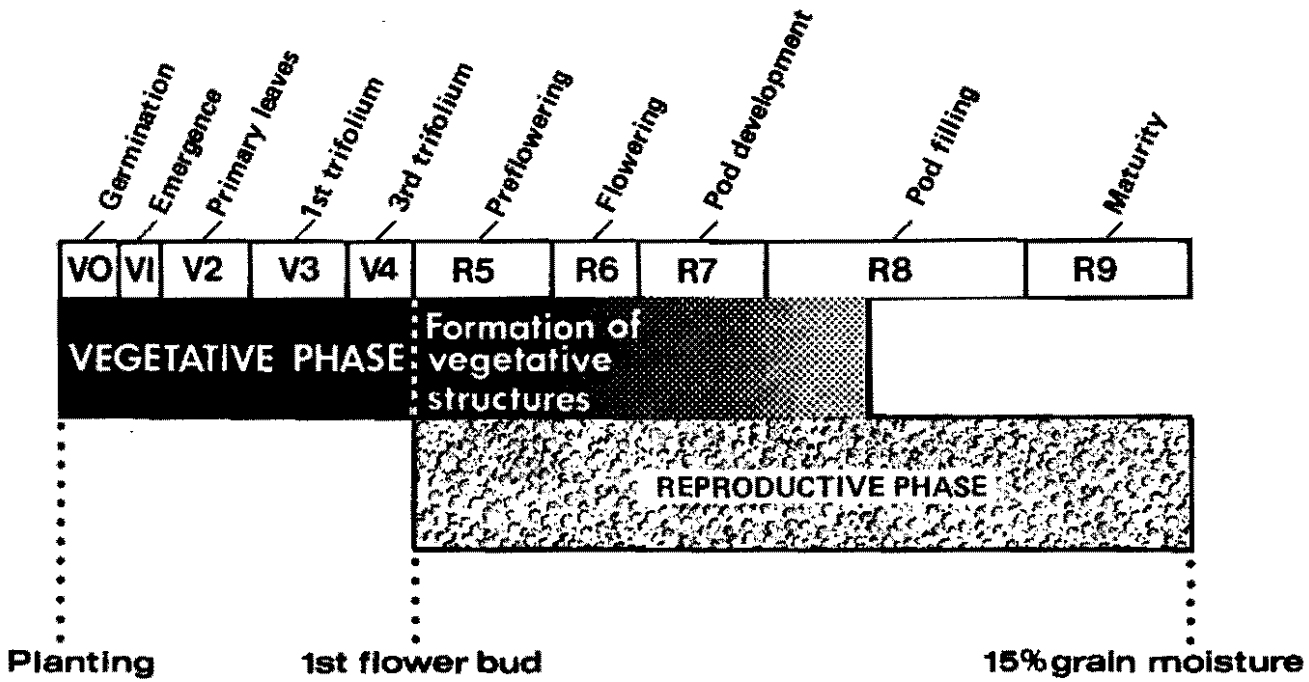

Figure 1. Phases and stages of development of the bean plant.

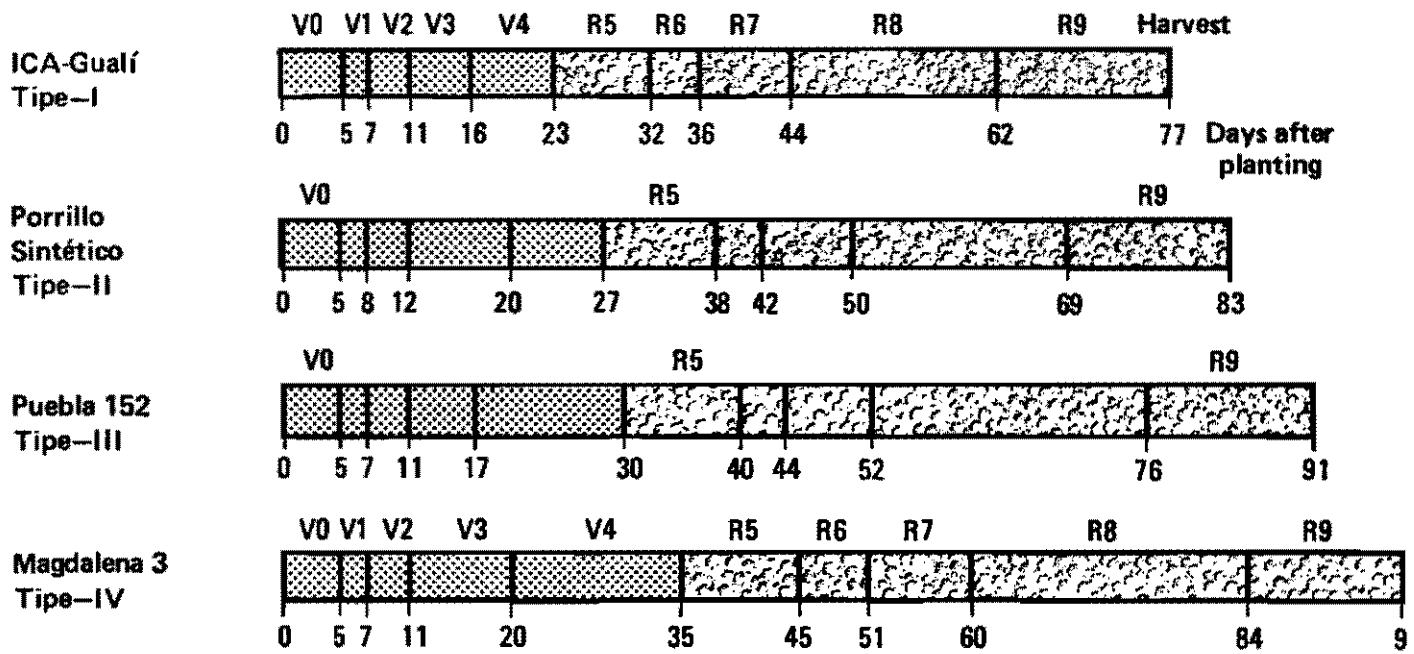

Figure 2. Number of days after planting for each stage of development of four varieties of four different growth habits, CIAT Palmira 24°C 1000 m. asl.

Stage V 1, EMERGENCE : From the moment the cotyledons appear on the surface of the soil. The hypocotyl strainghtens, the cotiledons spread apart, the epicotyl starts developing and finally the primary leaves unfold.

Stage V 2, PRIMARY LEAVES : The primary leaves, located in the second node of the stem (first node after the cotiledonary node) are now fully unfolded and in horizontal position. The cotyledons have sriveled and appear arched. The first trifoliate leave is already apparent, unfolding.

Stage V 3, FIRST TRIFOLIATE LEAF : Starts when the plant presents the first trifoliate leaf fully open and in horizontal position. The leaf continues to increase its size. The internodes are very short thus the first trifoliate leaf at the start of this stage is below the level of the primary leaves. Then the internode elongates raising that leaf above the level of the primary leaves. The second trifoliate leaf in the meantime, unfolds fully to a horizontal position.

The first branch usually begins its growth when the plant is in stage V3. From then on, leaves appear on the first branches and other branches form.

Stage V 4, THIRD TRIFOLIATE LEAF : Starts when the third trifoliate leaf is fully unfolded. At this point the third leaf is still below the level of the second leaf. From this stage on some vegetative structures that have been undergoing differentiations, are distinguishable, such as the stem, branches and other trifoliate leaves that develop from triads in the nodes at the axil of leaves. The buds of triads at the base of the plant in the first to third node generally produce branches, the type of branching depending on genotype, population and growing conditions.

Stage R 5, PREFLOWERING : Begins with the appearance of the first floral bud (or raceme in undeterminate plants). In a variety of determinate growth habit the floral buds develop in the last (terminal) node of the stem and the growth of stem and branches cease. In the indeterminate varieties the racemes are noticeable in the lower nodes, the stem and branches continue to grow since they have apical growth meristems instead of apical flower buds.

The flower buds and racemes may be distinguished from vegetative buds by their rounded appearance and the bracts of the flower buds and racemes, whereas in the vegetative-branch buds the most notorious organs are the triangular stipules. The flower buds develop and swell one day before anthesis showing also pigmentation typical of the variety.

Stage R 6, FLOWERING : Initiates when the first flower opens (anthesis) In determinate growth varieties flowering starts at the top of the plant and moves downward. In undeterminate varieties flowering starts in the basal branches and moves upward. Flowering in the branches occurs in the same pattern as in the main stem. Once the

pollen is shed and fertilization occurs, the corolla drops out and the pod starts its elongation.

Stage R 7, POD DEVELOPMENT : Starts with the expansion of the ovary right after the anthesis but becomes noticeable when the plant shows the first pod with the corolla fallen out or hanging loosely from the incipient pod. Pods appear in the same pattern as flowering occured. At first the pod elongates rapidly (about twelve days after flowering) with very little growth of the seeds until the pod has reached its full size;in about fifteen to thirty days after flowering at 24° mean temperature.

Stage R 8, POD FILLING : The first pod starts filling by increasing size and weight of the seeds. Soon, laterally, the pods present "bulging" as seeds reach full size. The grains increase to full weight thirty to thirty five days after flowering at 24° mean temperature.

At the end of this stage the grains loose its green color and start to acquire the pigmentation typical of the variety. In some genotypes the pods also acquire pigmentation at this stage. Some discoloration and senescense of leaves occurs at the end of this stage.

Stage R 9, MATURITY : This is the last stage in the scale, it is characterized by senescense of the leaves, which discolor, dry up and fall. All parts of the plant dry up, the pods loose its pigmentation. The water content of the seeds drops to about 15% and the plant has completed its growth cycle.

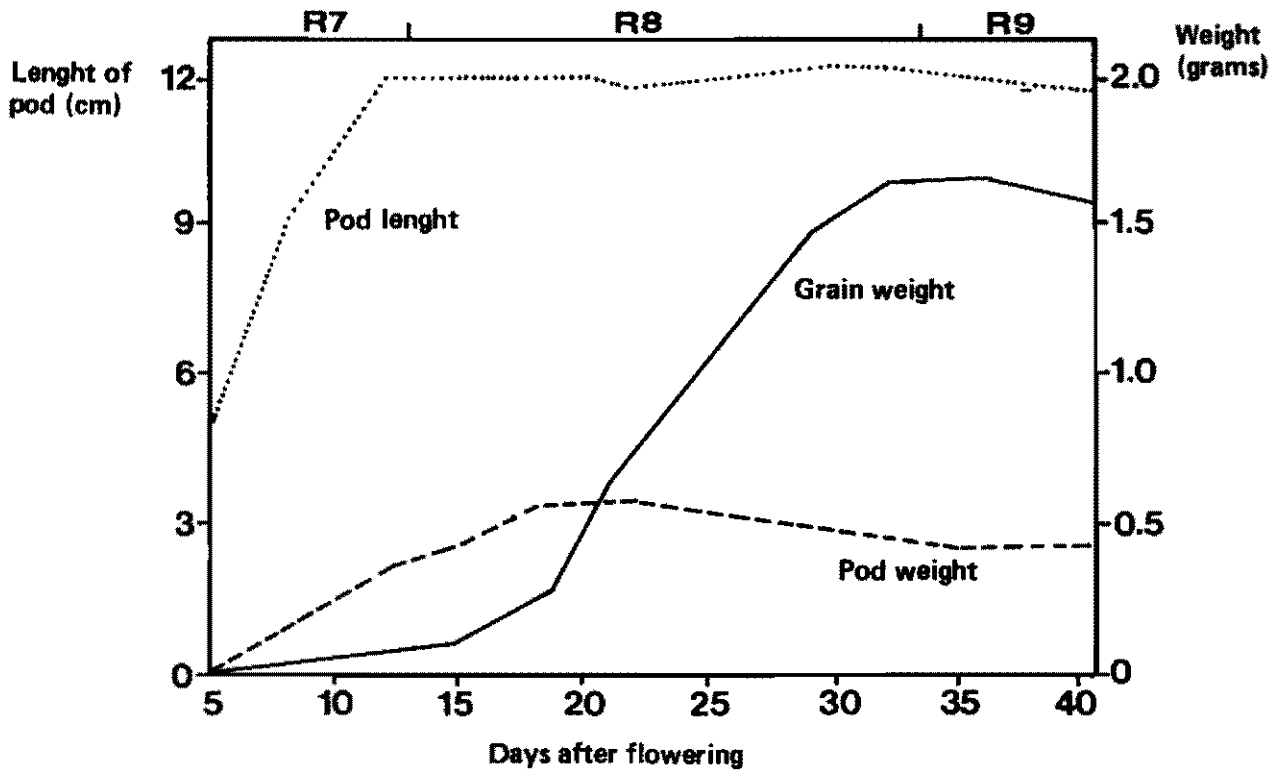

Figure 3. Size, pod weight and grain weight in the variety Porrillo Sintetico.