

Application of the "Extended BBCH - Scale" for the description of the growth stages of coffee (*Coffea* sp.)

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**APPLICATION OF THE "EXTENDED
BBCH - SCALE" FOR THE DESCRIPTION OF THE
GROWTH STAGES OF COFFEE (*Coffea* sp.)¹**

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SUMMARY

The “Extended BBCH - Scale” and its associated decimal code were applied for the description of the growth stages of the coffee plant. Principal growth stages include germination and vegetative propagation, leaf development on shoot of the young plant and branches in the tree, formation of branches, branch elongation, inflorescence and flower development, flowering, development of fruit, ripening of fruit and seed, and senescence. Secondary stages were also identified for each of the principal stages.

Through a two digit decimal code it is possible to identify the principal growth stages and their respective secondary stages. This scale will be of great help to coffee growers and researchers around the world for more efficient planning of management practices and experiments.

The description herein can vary in special circumstances that affect normal plant growth such as nutritional disorders, diseases and pests.

1. INTRODUCTION

Coffee is one of the most important Primary commodities in nearly 70 countries in the humid tropics. It is cultivated in 10 million hectares and world production is around 5 million tons of green coffee of which 69% come from *C. arabica*, 30% from *C. canephora* and 1% from *C. liberica*. Brazil, Colombia and Indonesia cover 50% of the world market (CIRAD, 1994 and 1995; Santos *et al.*, 1995; USDA, 1995).

Coffea is the major genus of the family Rubiaceae, which includes more than 400 genera and species, mostly trees and shrubs. The economically important species are *C. arabica*, *C. canephora* and *C. liberica* (Berthaud and Charrier, 1988; Wrigley, 1988).

C. arabica is allotetraploid ($2n=44$), 90% autogamous and propagated mostly through seeds. Commercial cultivars are tall (4-6m height) or dwarf (2-3m height). Some traditional tall cultivars are Arabica (Typica), Bourbon, and Mundo Novo, cultivated

mainly in America; SL26, and K7 in Kenya and S795 in India. Dwarf varieties such as Caturra, Catuai, Colombia, Catimor, are cultivated mainly in America, Ruiru 11 in Kenya. At present cultivation is intensive at high altitudes (1200-2000 m) in America and East Africa (Berthaud and Charrier, 1988; Mitchell, 1988).

C. canephora is diploid ($2n=22$) and allogamous; it is propagated through seeds or vegetatively. It is a robust glabrous shrub or small tree growing up to 10 m in height. It includes tall varieties such as Kouilou, Conilon, and Robusta and some selected hybrid materials. It is widely grown at low altitudes, in West Africa (Ivory Coast, Congo), Brazil, and Indonesia (Berthaud and Charrier, 1988; Snoeck, 1988).

C. liberica is diploid ($2n=22$) and allogamous. It generally grows taller than the other species, reaching between 5-17 m height. It thrives From Southern Guinea through Ivory Coast,

Liberia, Ghana, Zaire, to Northern Angola. Fruits are much bigger than those of *C. arabica* and *C. canephora* (Berthaud and Charrier, 1988; Wrigley, 1988).

Although tall coffee varieties are still cultivated in many regions, the tendency today is towards intensive cultivation of dwarf, highly productive, disease resistant cultivars (CIRAD, 1995).

The knowledge of the phenology of the crop is

important for the correct timing of management practices such as fertilizer application, disease, pest, and weed control among others. There are several descriptions of coffee tree growth stages (Arcila *et al.*, 1993; Arcila, 1990; Camargo, 1985; Cannell, 1985; De Reffye *et al.* 1989; Fournier and Herrera, 1983; Snoeck, 1991; Trojer, 1968; Zimbabwe Coffee Growers Association, 1987) and as is the case for the majority of cultivated plants there is not an universal language for these descriptions. Most refer to a specific growth stage and no effort has

been realized to establish a full description of coffee growth stages for a generalized use.

Since the proposal of Zadocks *et al.* (1974), of a decimal code for the description of the growth stages of cereals, there has been a growing interest on the extension of these general principles for the description of the growth stages of world main crops including monocotyledones, dycotiledones, gramineae and perennials (Agusti *et al.*, 1995; Bleiholder *et al.*, 1991; Lancashire *et al.*, 1991).

In recent years, and based upon Zadock's descriptions, a uniform decimal code, known as the BBCH-scale, was proposed by Bleiholder *et al.* (1991), Lancashire *et al.* (1991) and Hack *et al.* (1992). A more advanced scale, The "Extended BBCH-scale" was proposed by Hack *et al.* (1992) and Hess *et al.* (1997). According to this universal scale, using a phenological criteria and a consistent set of numeric codes, it is possible to establish a uniform coding to describe the growth stages of a maximum number of plant species.

2. CHARACTERISTICS OF THE GROWTH SCALE FOR THE COFFEE TREE

2.1 GROWTH OF THE COFFEE PLANT

Growth of the coffee plant takes place from meristematic cells located in the apex of stem and branches and in the axils of leaves. From these meristems, node, leaf, branch and flower primordia develop. The shoot apex is responsible for node, leaf formation and height growth on main stem (orthotropic growth). Branch apex is responsible for node, leaf formation and lateral growth on branches (plagiotropic growth) (Moens,1968).

At certain distance from the apex of stem and branches, in the leaf axils, a series of 4-5 buds are formed from which flowers or branches differentiate. When located on the main shoot, the first and oldest of these buds gives rise only to lateral shoots (primary branches) and one pair of opposite branches is formed per node. The following bud of the series originates vertical shoots (suckers). The other

buds remain dormant or eventually form flowers (cauline flowers). When the buds are located on branches, their main destination is to form flowers and those that do not differentiate into flowers, form secondary or tertiary branches. The coffee tree starts bearing fruit on branches one year old and will continue bearing fruits for 20 or more years with greatest productivity between 5-10 years of age. Nodes bear fruits only once (Moens,1968).

Coffee cropping systems in the world include exploitation of trees growing naturally in the forest, cultivation of coffee trees under some remaining forest trees, cultivation under planted shade trees, systematic cultivation under

overhead shade trees or full sunlight, mixed cropping system with perennials or intercrops. These production systems involve the cultivation and maintenance of coffee shrubs in the field and the harvesting and processing (wet or dry) of the coffee berries (CIRAD,1995; Mitchell,1988;Snoeck, 1988; Wrigley,1988).

The pulping, fermenting and drying of the berries Are post harvest events.

2.2 PRINCIPAL GROWTH STAGES

The "Extended BBCH scale" (Bleiholder *et al.* 1991; Lancashire *et al.* 1991) considers 10 principal growth stages numbered from 0 to 9. For the coffee plant, these

initiate with the germination of seeds or shoot development in cuttings or stumps (Stage 0). The vegetative growth is considered under three macrostages corresponding to leaf development in seedlings in the nursery and branches (Stage 1),

formation of branches (stage 2), and elongation of branches (stage 3).

Inflorescence emergence and flower development are considered under stage 5. Flowering (stage 6), development of fruit (stage 7), ripening of the fruit and seed (stage 8) and senescence (stage 9) complete the scale.

Development of vegetative harvestable (stage 4) parts are not considered because they do not apply in coffee.

2.3 SECONDARY GROWTH STAGES

Secondary growth stages are also numbered from 0 to 9 which correspond to ordinal or percentage values of development. For example for leaf

development (stage 1), the fifth true leaf pair is assigned a value of 5 and its identification in the scale will be 15; for branch elongation (stage 3), when 20 nodes are present, a value of 2 is given and its identification in the scale will be 32. In the same

manner, if 10% of flowers are open, this characteristic is given a value of 1 within the principal stage 6 (flowering) and will be defined as 61 in the scale. For fruit ripening, the change of color was the criteria chosen, thus, stage 88 corresponds to fruits fully red and ready for picking and the stage 89 mean that fruits are overripe or decaying.

3. DESCRIPTION OF THE PRIMARY AND SECONDARY GROWTH STAGES OF THE COFFEE PLANT

The descriptions below are intended for average ambient conditions for Coffee growth, that is, 23 -17 °C (average day - night temperature), monthly

rainfall of at least 120 mm, less than 13.5h daylight (Camargo, 1985; Cannell, 1985;Maestri and Santos, 1981; Santos *et al.*, 1978; Wrigley, 1988). Although some variation in the timing of the growth stages do occur among cultivated species, varieties and regions, the scale can still be applied under this circumstances.

3.1 PRINCIPAL GROWTH STAGE

0

Germination/vegetative propagation

The coffee seed reaches physiological maturity around 200 days after flowering and is harvested at 240 days (Salazar *et al.*, 1994). After harvest (picking of red berries) and processing (removal of pulp and mucilage and drying) the seed has 11-12% moisture content and presents a beige color if parchment is Present or bluish-green color

when parchment and silver skin are removed («dry seed», stage 00). The germination has a duration of approximately 9 weeks. After one week of start of germination, imbibition is completed (stage 03) and the bean appears swollen and whitish in color and the radicle is not yet visible. After three weeks radicle protrusion and hooking are

visible (stage 05). Radicle elongation and formation of root hairs follows (stage 06). At seven weeks nearly 90% of seeds have emerged from soil (“emergence”) and show the hypocotile with cotyledons still enclosed in the parchment (stage 09), (Arcila,1988;Huxley,1965).

Another form of Propagation of coffee



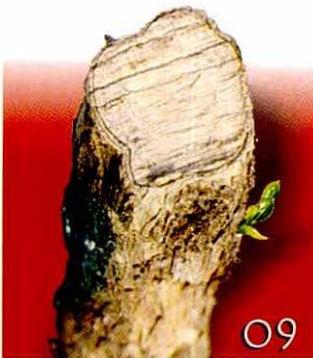
plants, specially *C. canephora*, is through cuttings (stage 0). Once the cuttings (orthotropic, mononodal, 60 mm long, two half trimmed leaves) (stage 00), are planted in the rooting media (stage 01), callus formation begins after about 3 weeks (stage 03) and is completed after 5-6 weeks. About 50% of the cuttings should form shoots and roots in the first nine weeks after setting out (stage 05) and about 75% in the next four weeks (stage 07).

When the cuttings present roots 6-7 cm long and shoots with 1-2 nodes (stage 09) they are ready for transplant and nursery care (Snoeck,1988). In some countries, after finishing a growth round of 5-6 harvests the plantation is stumped to reinitiate a new cultivation cycle(Mitchell,1988; wrigley,1988).Two to three months after stumping there is formation of numerous shoots from which one to three are selected For further growth. This practice can be

considered as a form of vegetative propagation (stage 0). At the beginning, the stumps present on the nodes some bulky formations (cluster of dormant buds) and buds are not yet visible (stage 00).

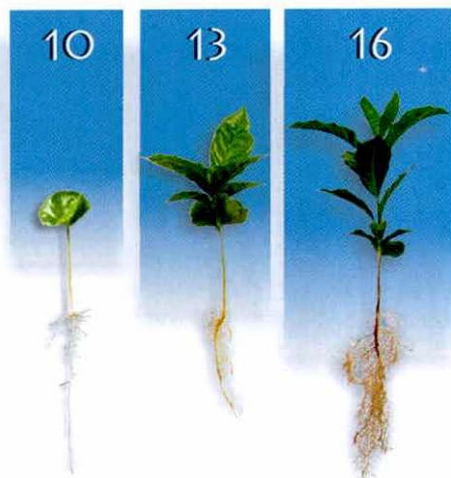
One month later buds become visible as small green scales (stage 03). When buds are visible as small, green, rounded structures with shoot initials, stage 05 has been reached. When stumps show sprouts with first leaf initials on the nodes, the sprouting process is completed (stage 09).

Thereafter, development continues as that of the main shoot (Arcila,1988; Wrigley, 1988).



Sprout outbreak after stumping

Leaf development on main shoot of the young plant and on the branches of the coffee tree



Here, the development of leaves in the main shoot of the young plant is considered and also the development on branches of the coffee tree. For the young plant, each leaf pair is counted, whereas for the coffee tree the leaf pairs are described regarding the development on each of a single branch of most of the branches of the tree.

Leaf development in the coffee plant occurs in pairs and it is associated with node formation on stem and branches. In each node two opposite leaves are formed.

At nine weeks after sowing of the seed, the cotyledons appear fully expanded and the first pair of true leaves begin to separate on the shoot (stage 10); leaf development on branches begin with separation of first leaves, stage 10 (Arcila, 1988; Huxley, 1965). The young leaf pairs are light green or bronze color depending on cultivar and when mature they are dark green, (stages 11 and 12). Foliage development is seasonal and a five year old

C. arabica plant of the caturra type might reach nearly 25 m² of leaf area (Arcila and Chaves, 1995). When three pairs of leaves are present, stage 13 is completed. When 9 or more pairs of leaves are present, stage 19 is reached. The same description applies for the development of first leaves in the shoots and branches of cuttings and stumps.

Formation of branches (only for plants in the field)

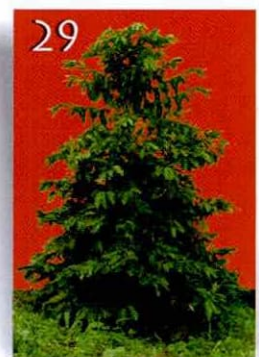
In annual crops the vegetative phase covers the period between sowing and first flowering. However, in the case of perennial crops such as coffee, it is very difficult to define a vegetative phase, because node and leaf formation occurs periodically (one or two annual cycles) and sometimes it coincides with flower and fruit development (Arcila and Chaves, 1995; Arcila, 1990; Cannell, 1985; Maestri and Santos, 1981).

Beyond the sixth node of main shoot of the young plant, in each of the leaf axils, there are 4-6 serial buds, the first of these (oldest) gives rise to a

plagiotropic branch (primary branch). At each node two opposite branches are formed. The remaining buds give rise to orthotropic branches (suckers) and occasionally to flowers. In each of the leaf axils of plagiotropic branches 3-4 serial buds are also found and they differentiate mainly into flowers. However, some of these buds might be triggered by internal and external factors and form lateral branches (secondary branch) in a random fashion. In a similar way tertiary branches form on secondary branches (Moens, 1968).

When 6-7 nodes have formed on the main shoot,

the first pair of primary branches becomes visible at the second node from the shoot apex (stage 20). If a six year growth cycle is considered, when 10 pair of branches are formed on the main stem, stage 21 is reached. When 30 pairs of branches are present, stage 23 has been reached and so forth, stage 29 means that 90 or more pairs of primary branches have been formed (De Reffye *et al.*, 1989; Salazar *et al.*, 1989; Snoeck, 1991).



3.4 PRINCIPAL GROWTH STAGE

3

Branch elongation (primary, secondary and tertiary)

Branches start to elongate by node formation at the apex and internode elongation.

At the beginning it is observed at the tip of the branch a small and unfolded pair of leaves and the first node is just visible. In each node a pair of opposite leaves is formed. When 10 nodes have formed, stage 31 is reached. When 50 nodes are present, stage 35 is defined. In the same way stage 37 means that 70 nodes are present in the branch. when stage 39 is reached the

branch will present 90 or more nodes. Because secondary branches form on primary branches and tertiary branches form on secondary, their nodes are included as belonging to the primary branch.



3.5 PRINCIPAL GROWTH STAGE

5

Inflorescence emergence

The flowering process of the coffee plant is complex (Camayo, 1995; Moens, 1968, Moncur, 1988; Santos *et al.* 1978). It has a duration of approximately 120 days. Two aspects must be considered: 1) Inflorescence

development in leaf axils (nodes in branches); 2) Single flower development in each inflorescence.

Three to five buds (inflorescence) form in the leaf axil and four to five flowers form in each

inflorescence. Several scales have been proposed to describe flower development (Camayo, 1995; Drinnan and Mentzel, 1994; Moens, 1968; Wormer, 1964). Flower development is composed of the following stages. The



51



54



first is the floral induction and inflorescence initiation which occurs at the molecular level, at a very fast rate and externally indistinguishable; at this stage the node is surrounded by light green scales and no swelling of the leaf axils is observed. Inflorescence development follows and it might last 30 ± 5 days. It begins with the swelling of leaf axils (stage 51). In the next phase inflorescence buds burst and they appear covered by a brownish mucilage and no flowers are visible (stage 53). In the following stage single green flowers are visible, tightly join, still closed, and born on multiflowered inflorescences (stage 57). It has a duration of approximately 45 days. When floral buttons reach a size of 4-6 mm and are still green and untight (stage 58), they stop growing and a dormancy period follows



57



59



which might have a duration of 30 or more days. This dormancy is apparently a true dormancy induced by continued experience of low water potentials by the bud or endogenous factors. Sudden relief of the water stress by a rain or irrigation, sudden drop of temperature, or applications of giberellic acid GA, bring about fast renewal of flower growth

which increase their length 3-4 fold and their petals, still closed, present a whitish color (stage 59) (Santos et al., 1978). This last step has a duration of 10-15 days.

Simultaneous flowering is characteristic in almost all regions where coffee is grown. In *C. arabica* the opening of flowers occurs over 3-4 days; in *C. canephora* the flowers tend to open all together in the same day (Camargo, 1985; Santos *et al.*, 1978; Wrigley, 1988).

Water stress appears to be essential for the normal development of the flowers; if buds do not experience it, they do not develop or develop abnormally. Floral buds usually mature during the dry season and open 10-15 days after the interruption of dry spells by rains (Cannell, 1985; Santos *et al.*, 1978).

In the equatorial regions where there are not well defined alternations of wet and dry seasons, the coffee trees flower at odd intervals, varying from two to several weeks and 12-15 flowerings can be registered in a year (Arcila *et al.*, 1993; Camargo, 1985; Trojer,

1968). This makes the scaling of the blossoming rather complicated. However a person with some experience in coffee cultivation can easily acquire the skills for grading the flowerings according to the scale proposed.

When about 10% of the flowers in a plant are open the blossoming stage is graded as 61. At stage 65, nearly 50% of the flowers

have opened. At stage 69 about 90% of the flowers have opened, very few flower remain and fruit set is the predominant stage. It is recommended to do this evaluations for six month periods.



Development of fruit

The fruit of *C. arabica* is an oval drupe, normally containing two seeds. It has a length of 10-15 mm and is usually called a cherry or a berry. The fruit take 7-8 months to mature depending on the variety and when mature, their skin is red (yellow in some varieties), covering a slippery sweet and

mucilaginous pulp. Inside the fruit, two seeds (coffee beans) lie with their flat sides together. Each of the two coffee beans is covered by a loose, thin yellowish skin (parchment), with a coating of thin mucilage. Underneath that skin is a thin and closely fitting membranous tegument, known as the silver skin. The beans of *C. arabica* are 9-12 mm long, 6-7 mm wide and 3-4mm thick, and weight about 0.15-0.20 g. The average weight ratio of cherries to clean coffee beans is 5.5 : 1

And clean coffee contains about 5000 beans per kg. In *C. canephora* the seeds are 8-9mm long, the proportion of cherry to dry beans is approximately 4.5: 1, and 1kg clean coffee contains 4500 beans. The fruits of *C. arabica* mature earlier (7-8 months) than those of *C. Canephora* (9-11 months), (Leon and Fournier, 1962; Salazar *et al.*, 1994; Wormer, 1964; Wrigley, 1988).

Fruit development takes approximately 220-240 days (Leon and Fournier, 1962; Salazar *et al.*, 1994). Because several stages of fruit development occur simultaneously during a six month period, the scale considers grading these stages for the predominant (more



71



73



77



79



than 50%) stage. After blossoming the petals blacken and fall and the small yellowish berries are visible (stage 70). Initially the fruits

grow very slow during the first 4-8 weeks, stage commonly referred to as «pinheads»(stage 71). After this period fruits start rapid growth and increase in volume for 10-11 weeks, they

are light green and their contents are liquid, they have reached about 30% of final size (stage 73). Fruits then appear dark green and the seed content solidifies (stage 77). About 28 weeks after blossoming the fruit is pale green, it has reached physiological maturity and is ready for maturation, it also has reached 90% of its final size (stage 79).

3.8 PRINCIPAL GROWTH STAGE

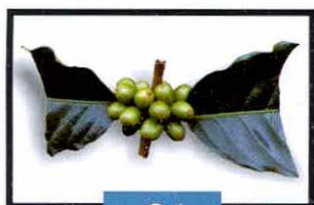
8

Ripening of fruit and seed

Once the fruit and seed have reached physiological maturity at about 200 days after

flowering, they start to change color from green to yellow (stage 81), then the fruit color increases in intensity and presents Yellow and red areas (stage

85) but it is not yet ready for picking. Finally at about 240 days it is completely red (or yellow in some cultivars) And ready for picking (stage 88).The fruit then turns dark red, starts to dry (stage 89) and remains on the tree or it might fall.The ripening process of the coffee berry might last 4-6 weeks.



81



85



88



Application of the "Extended BBCH - scale" for the description of the growth stages of coffee (*Coffea* sp.)

Senescence

The coffee plant is perennial and is considered that it reaches its maximum growth at 8-10 years of age. However the plant organs complete their life cycles at different ages and timings. When shoots have completed their

development the plant appears of an intense dark green color, leaves are of normal size and harvest locates at the bottom part of the plant (stage 90). Leaves have a duration of approximately 300 days. Older leaves change its Color from deep green to yellow with red spots, and fall specially at harvesting

time (stage 93). As plant ages the foliage changes to a pale green color signaling some degree of senescence, defoliation is observed on the bottom part of the main stem and lower branches (stage 94). After 3-4 harvests the production zone has moved towards the upper parts in the main shoot and outer parts of branches, leaves are of smaller size than normal, strong defoliation is observed on the bottom and inner parts of the plant, some dead branches are observed at the bottom (stage 97). When the



production zone is limited to a very few branches on

the top of the shoot and a very few nodes on the tip of these branches, and the

plant is heavily defoliated, a high degree of senescence has been reached (stage 98). Post harvest or storage treatments shall be included in stage 99.

3.10 PARTICULAR CHARACTERISTICS OF THE DEVELOPMENT OF THE COFFEE PLANT

During the life cycle of the coffee plant and specially in the equatorial regions where there is not an alternation of well

Defined wet and dry periods, there is an overlapping of vegetative and reproductive stages, for example:

- Bean filling of the first semester crop with flowerings for second semester crop; first semester harvest with fast growth of fruit for second semester harvest; flowerings for first semester crop with bean filling for second semester crop; rapid growth of fruits for first semester crop with ripening of second semester crop (Arcila, 1990; Cannell, 1985; Trojer, 1968).

This overlapping of stages originates competence for assimilates among organs and between the vegetative and reproductive stages and

might also alter the timing and scaling of stages. For grading these overlappings (parallel stages) both stages

can be differentiated by a slash, for example, 65/85.



Application of the "Extended BBCH - scale" for the description of the growth stages of coffee (*Coffea* sp.)

THE “EXTENDED BBCH - SCALE” FOR THE DESCRIPTION OF THE PHENOLOGICAL STAGES OF THE COFFEE PLANT

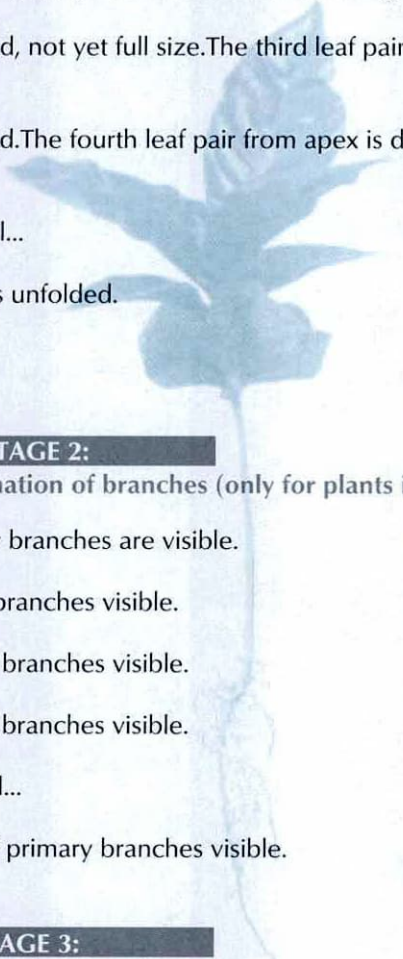
PRINCIPAL GROWTH STAGE 0:

Germination, vegetative propagation

-
- 00** Dry seed (11-12% moisture content), beige color if parchment present Or bluish-green if parchment and silver skin removed. Cutting (orthotropic, mononodal, 60 mm long, two half trimmed leaves). Stump with bulky nodes and no buds visible.
- 01** Beginning of seed imbibition, bean swollen, whitish, no radicle visible. Cutting planted in rooting media, no shoots visible, no callus visible.
- 03** Seed imbibition complete, bean whitish, small swelling visible at one end of bean where the embryo is located. Callus formation begins on cuttings. Bud burst start on stumps.
- 05** Seed radicle protrusion and hooking. Shoot and root formation on the cuttings. Green, rounded buds visible on the stumps.
- 06** Elongation of radicle, formation of root hairs and lateral roots on seeds and cuttings.
- 07** Hypocotyl with cotyledons breaking through the seed coat. Cuttings have formed shoots and branched roots.
- 09** *Emergence:* Seeds have emerged from soil and show the hypocotile with cotyledons still enclosed in the parchment. The cuttings present roots 6-7 cm. long and shoots with 1-2 nodes. Stumps show sprouts with first Leaf initials.

PRINCIPAL GROWTH STAGE 1:

Leaf development on main shoot of the young plant, and branches of the coffee tree

- 
- 10 Cotyledons completely unfolded. First pair of true leaves separating on shoot or first pair of true leaves separating on branch of the coffee tree.
 - 11 First leaf pair unfolded, not yet at full size. Leaves are light green or bronze.
 - 12 2 leaf pairs unfolded, not yet at full size. Leaves are light green or bronze.
 - 13 3 leaf pairs unfolded, not yet full size. The third leaf pair from apex is dark green.
 - 14 4 leaf pairs unfolded. The fourth leaf pair from apex is dark green and has Reached full size.
- Stages continues till...
- 19 9 or more leaf pairs unfolded.

PRINCIPAL GROWTH STAGE 2:

Formation of branches (only for plants in the field)

- 20 First pair of primary branches are visible.
 - 21 10 pair of primary branches visible.
 - 22 20 pairs of primary branches visible.
 - 23 30 pairs of primary branches visible.
- Stages continues till...
- 29 90 or more pairs of primary branches visible.

PRINCIPAL GROWTH STAGE 3:

Branch elongation

- 31 10 nodes present in the branch(es).
- 32 20 nodes present in the branch(es).

- 3. Stages continues till...
- 39 90 or more nodes present in the branch(es).

PRINCIPAL GROWTH STAGE 5:

Inflorescence emergence

- 51 Inflorescence buds swelling in leaf axils.
 - 53 Inflorescence buds burst and covered by brown mucilage; no flowers visible.
 - 57 Flowers visible, still closed and tightly join, borne on multiflowered inflorescence (3-4 flowers per inflorescence).
 - 58 Flowers visible, untight, still closed, petals 4-6 mm long and green (dormant stage).
 - 59 Flowers with petals elongated (6-10 mm long), still closed and white color.
- Two aspects are considered: 1) Inflorescence development in leaf axils (nodes in branches); 2) Single flower development in each inflorescence.

PRINCIPAL GROWTH STAGE 6:

Flowering

- 60 First flowers open.
- 61 10% of flowers open.
- 63 30% of flowers open.
- 65 50% of flowers open.
- 67 70% of flowers open.
- 69 90% of flowers open.

PRINCIPAL GROWTH STAGE 7:

Development of fruit

- 70** Fruits visible as small yellowish berries.
- 71** *Fruit set*: Beginning of berry growth. Fruits have reached 10% of final size (pinheads).
- 73** Fruits are light green and contents are liquid and crystalline. Fruits have reached 30% of final size (fast growth).
- 75** Fruits are light green and its contents are liquid and crystalline. Fruits have reached 50% of final size.
- 77** Fruits are dark green and its contents are solid and white. Fruits have reached % of final size.
- 79** Fruits are pale green and its contents are solid and white. Physiological maturity is complete. Fruits have reached 90% of final size.

PRINCIPAL GROWTH STAGE 8 :

Ripening of fruit and seed

- 81** Beginning of change of fruit coloration from pale green to yellow or red.
- 85** Increase in intensity (variety-specific), yellow or red , fruit color; fruit not yet ready for picking.
- 88** Fruit is fully-ripe color and ready for picking.
- 89** Overripe; beginning of darkening or drying; fruits stay on the tree or abscission begins.

PRINCIPAL GROWTH STAGE 9:

Senescence

- 90** Shoots have completed their development; the plant appears of an intense dark green color, leaves are of normal size and harvest locates at the bottom part of the plant.
- 93** Older leaves change its color from deep green to yellow with red spots, and fall specially at harvesting time.

94

The foliage changes to a pale green color. Defoliation is observed on the bottom part of the main stem and lower branches.

97

The production zone has moved towards the upper parts in the main shoot and outer parts of branches, leaves are of smaller size than normal, strong defoliation is observed on the bottom and inner part of the plant, some dead branches are observed at the bottom.

98

The production zone is limited to a very few branches on the top of the shoot and a very few nodes on the tip of these branches, and the plant is heavily defoliated. A high-degree of senescence has been reached. 90% or more of the harvest completed.

99

Post harvest or storage treatments.

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