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RESEARCH ARTICLE

Phenology of Vegetative Growth of Selected Mango Varieties in West Garo Hills of Meghalaya

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Abstract

Phenological stages of vegetative growth of mango varieties viz., Dashehari, Kesar and Amrapali were observed using the extended BBCH scale for mango proposed by Hernandez Delgado *et al*. (2010). The dates of occurrence of the principal stages of bud development (stage 1), leaf development (stage 2) and shoot development (stage 3), and the time required for transition from one phenophase to the next were recorded. Vegetative growth was observed in four flushes of bud (011–019, 021–029, 031–039 and 041–049), leaf (110–119, 120–129, 130–139 and 140–149) and shoot (311-319, 321-329, 331-339 and 341-349) development in the three varieties. Variety Amrapali completed bud development (011-019) in 16-35 days while Dashehari required 23-37 days and Kesar required 20 to 36 days for completion of bud development. Leaf development (110-119) was completed in 9 to 19 days in Amrapali, 12 to 24 days in Dashehari and 8-23 days in Kesar. Shoot development (311-319) in Amrapali required 15 to 51 days, 20 to 39 days in Dashehari and 20 to 46 days in Kesar. The time required for the transition from the beginning of leaf bud swelling (011) to end of leaf bud swelling (013) was the maximum (12–25 days in Amrapali, 17–25 days in Dashehari and16–25 days in Kesar) compared to a transition period of other phenophases. The total time required for completion of vegetative flush, starting from leaf bud swelling (011) to completion of shoot development (319) was 40 to 105 days in variety Amrapali, 55 to 100 days in Dashehari and 48 to 105 days in Kesar. The data on time required for the transition of one phenophase to the next can help in advance planning and effective implementation of various plant protection measures, growth regulator treatments and manure or fertilizer treatments for a variety in a particular agro-climatic condition, which are crucial for its vegetative growth and vigour which ultimately influences the flowering and fruiting of a variety.

Keywords: Phenology, vegetative flush, bud development, leaf development, shoot development, mango.

Introduction

Phenology is the study of the sequence of all recurring events in the life cycle of a plant (Schwartz 1999). "The knowledge of the timing of phenological events of a crop and their variability is important for planning, organizing and timely execution of cultural activities during cultivation, that require advance information on the dates of specific stages of crop development" (Ruml and Vulic 2005). Prior to the eighties, phenological stages were usually characterized by a combination of letters and numbers. The BBCH-scale (Biologische Bundesantalt, Bundessortenamt and Chemische Industrie) proposed by Bleiholder *et al*. (1989) and the extended BBCH scale proposed by Hack *et al*. (1992) were a remarkable development in recording phenological data. Since then, the BBCH scale has been widely applied for several crop species as it describes the vegetative and reproductive stages of plant growth.

Mango (*Mangifera indica L.*) belonging to the family Anacardiaceae is an important commercial fruit crop of India, well adapted to tropical and sub-tropical climates. Variations are observed in the growth and production of a mango variety when grown at different locations due to different agro-climatic conditions. Rajan *et al*. (2011) used the extended BBCH-scale proposed by Hernandez Delgado *et al*. (2010) for collecting phenological data on mango from five diverse eco-geographical locations of India, and stated that "the scale is easy to use as it includes all the subtle details of mango growth and development". Phenological observations using the extended BBCH scale have also been conducted in other fruit crops by Wei *et al.* (2013), Liu *et al.* (2015) and Kishore (2018). Understanding the different phenological events of a plant, knowledge of their time of

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occurrence and variability of a phenophase can be of great help to growers in planning and scheduling activities like manuring, irrigation, plant protection measures, application of growth regulators, harvesting etc. Phenological studies on commercial mango varieties have not yet been reported from the West Garo Hills of Meghalaya. Therefore, efforts were made to study the phenology of vegetative growth of three varieties of mango viz., Dashehari, Kesar and Amrapali grown in the region using the extended BBCH scale.

Materials and Methods

The study was conducted at the Instructional Farm, Department of Rural Development and Agricultural Production (RDAP), North Eastern Hill University, Tura Campus, West Garo Hills District, Meghalaya, India. The farm is located in Rongram block of West Garo Hills which is located approximately between $90^0$23′E latitude and 25^0 56′ N longitude at an elevation of 349 m above msl. The climate of the district is largely controlled by South-West monsoon and seasonal winds, and experiences fairly high temperature during most part of the year. The mean minimum and maximum temperature during the year 2017 was 15 and 32°C, respectively with a total rainfall of 438.44 cm and average relative humidity of 72.62%. The mean minimum and maximum temperature during the year 2018 was 16 and 33°C respectively with a total rainfall of 126.69 cm and an average relative humidity of 74.95%.

The extended BBCH scale for mango proposed by Hernandez Delgado *et al*. (2010) was used for observing phenological stages of vegetative growth of 13 years old healthy trees of mango varieties Dashehari, Kesar and Amrapali planted at a spacing of 5m x 5m. Seven trees of each variety were selected randomly for the observations and forty leaf buds per tree were tagged for observations during the period 2017 -2019. All the trees received uniform cultural practices. The first digit of the numerical code of the extended BBCH scale depicts the principal growth stage. The second digit of the principal growth stages of bud (stage 1), leaf (stage 2) and shoot development (stage 3) denotes mesostages occurring between principal and secondary vegetative growth stages. These mesostages can be 2 or more depending on the number of flushes. The third digit of the code denotes the percent growth of leaf buds, leaves, and shoots. The dates of occurrence of each phenophase and the time required for transition from one phenophase to the next were recorded and representative photographs of each phenophase were taken.

Results and Discussion

Intensive observations were made during the period 2017-2019 to record the dates of occurrence of each phenophase of the principal growth stages of vegetative growth like bud development (stage 0), leaf development (stage 1) and shoot development (stage 3) of mango varieties Dashehari, Kesar and Amrapali . Vegetative growth was observed in four flushes of bud (011–019, 021–029, 031–039 and 041–049), leaf (110–119, 120–129, 130–139 and 140–149) and shoot (311–319, 321–329, 331–339 and 341–349) development in all the three varieties during the period of observation (Figs 1 and 2). However, the 4th vegetative flush produced very few shoots in the three varieties and the shoot development stage of the 4th flush extended into the 1st month of the next year. Ramirez and Davenport (2010) reported that "one to four vegetative flushes may occur between flowering flushes in mango depending on the vigor of the tree".

In variety Amrapali, bud development stages of first vegetative flush (011–019) marked by the beginning of leaf bud swelling with bud scales beginning to separate (011), was observed from standard week 6 to 21 (February 1st week - May 4th week) in the year 2017 (Fig.1) while in the year 2018 it was observed from standard week 7 to 20 (February 3rd week - May 3rd week) (Fig.2). The leaf development and shoot development stages of first flush occurred more or less at the same time in both the years. There was not much variation in the time of occurrence of second, third and fourth vegetative flush in both the years of observation (Figs 1 and 2). The pooled values of time required for the transition of one phenophase to the next are depicted in Fig.3.

In the variety Dashehari**,** bud development stages of the first vegetative flush were noted at the same time as in Amrapali in the years 2017 and 2018. There was not much variation in the time of occurrence of leaf and shoot development stages of first vegetative flush in both years (Figs 1 and 2). It was noted that bud development, leaf development and shoot development of the second vegetative flush started more or less at the same time in both years but was extended by 6 to 7 weeks in the year 2018 (Fig.2). The third vegetative flush was delayed by 3 weeks in the year 2018 (Fig.2) compared to 2017 (Fig.1). The fourth vegetative flush was recorded more or less at the same time in both the years (Figs 1 and 2). The time taken (pooled values) for changing from one phenophase to the next is shown in Fig. 4.

In variety Kesar, first vegetative flush in the year 2017 was observed from standard week 5 (January end) (Fig. 1) but was delayed by 2 weeks in the year 2018 (Fig.2). Bud development, leaf development and shoot development of second vegetative flush started more or less at the same time in both the years but was extended by 4-5 weeks in the year 2018 (Fig. 2). Third vegetative flush in 2017 started from standard week 26 (June 4th week) (Fig. 1) but was delayed by 6 weeks in the year 2018 (Fig. 2). The fourth vegetative flush in 2017 started from standard week 38 (September 3rd week) (Fig. 1) but was delayed by 2 weeks in the year 2018 (Fig. 2). The time required (pooled values) for transition of one phenophase of vegetative growth to the next is exhibited in Fig. 5.

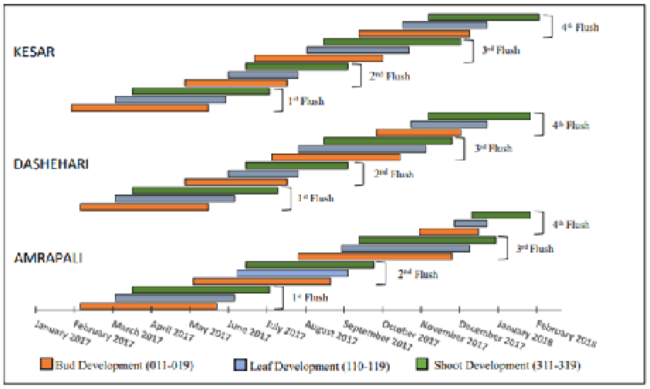

Figure 1: Vegetative flushing period in selected mango varieties in the year 2017

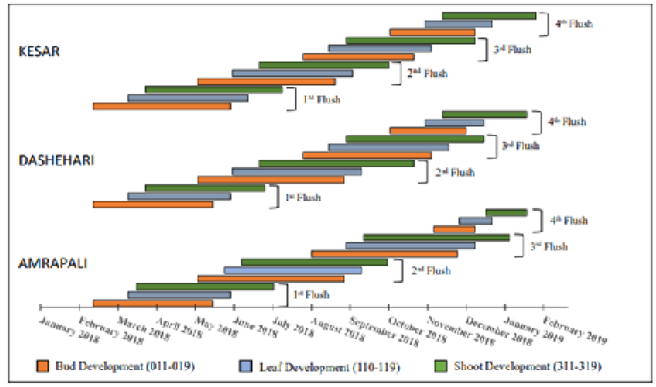

Figure 2: Vegetative flushing period in selected mango varieties in the year 2018

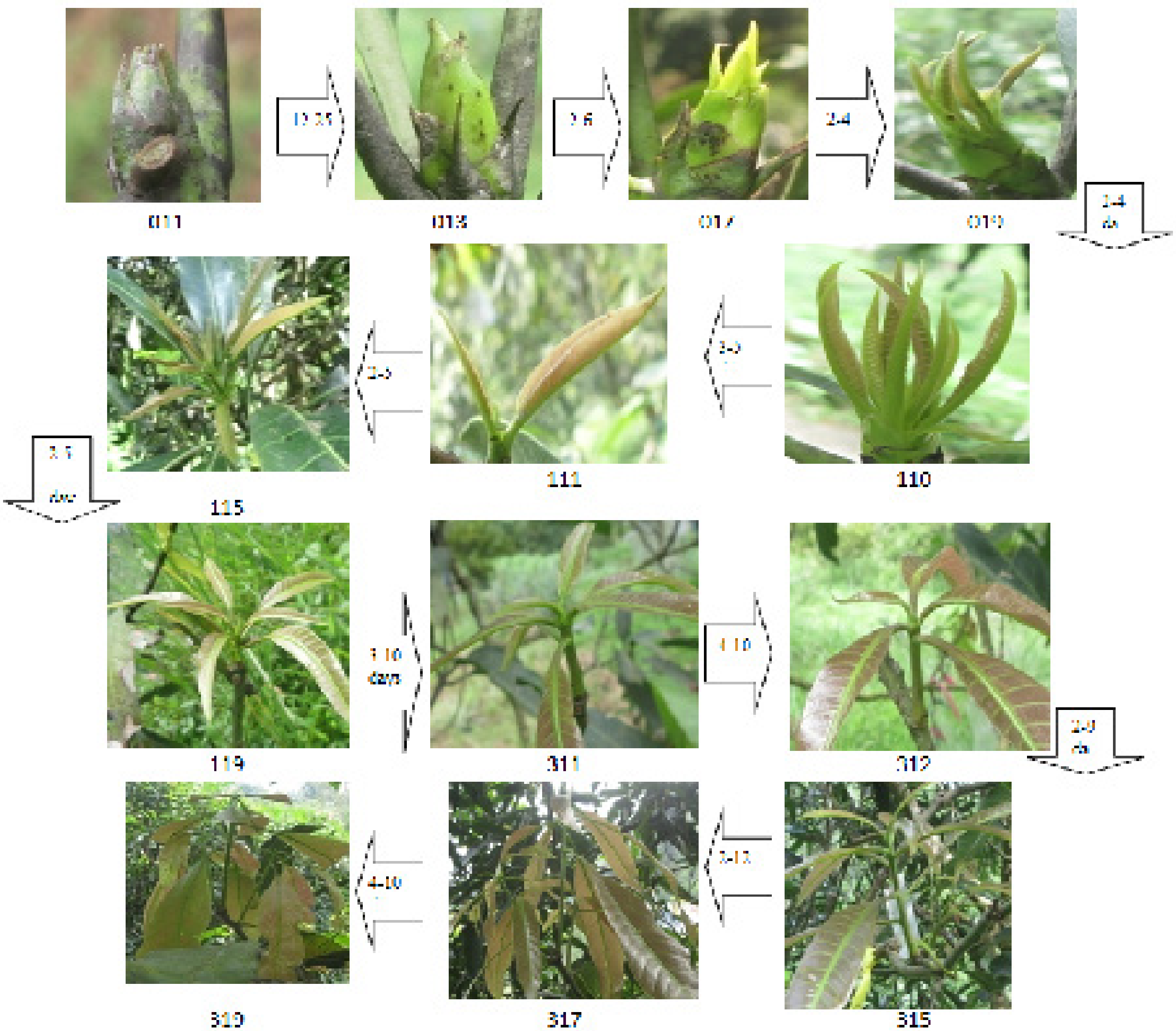

Figure 3: Time required for transition of phenophases of vegetative growth in mango variety Amrapali.
(Days shown in arrows are pooled values of 2 years observations)

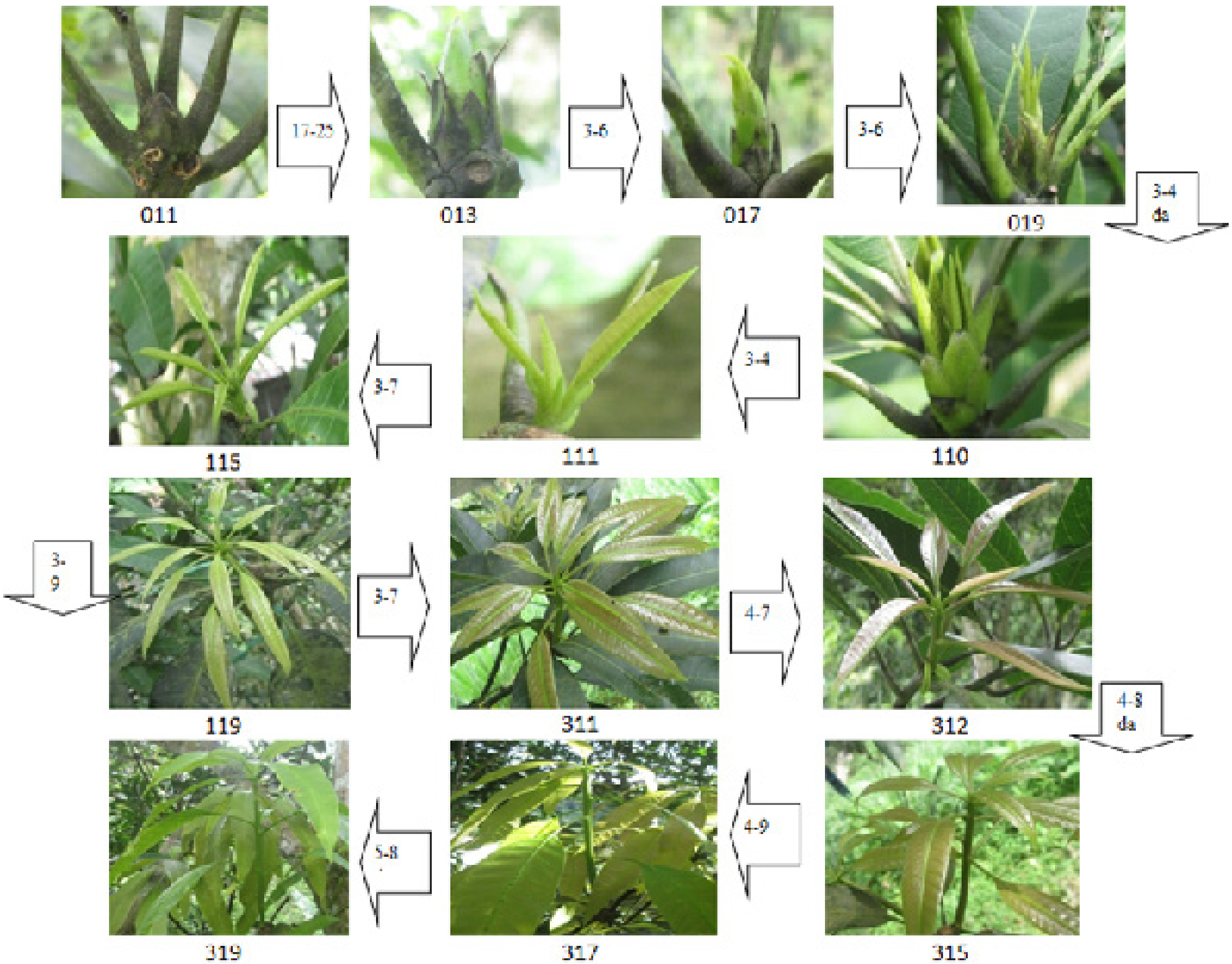

Figure 4: Time required for transition of phenophases of vegetative growth in mango variety Dashehari. (Days shown in arrows are pooled values of 2 years observations)

Variety Amrapali completed bud development (011-019) in 16-35 days, leaf development (110–119) in 9 to 19 days and shoot development (311–319) in 15 to 51 days. Variety Dashehari required 23 to 37 days for completion of bud development (011–019), 12-24 days for leaf development (110–119) and 20 to 39 days for shoot development (311–319). Variety Kesar completed bud development (011–019) in 20 to 36 days, leaf development (110–119) in 8 to 23 days and shoot development (311–319) in 20 to 46 days. Davenport (2009) reported that "development of vegetative shoot from initiation to full elongation requires 3 to 6 weeks in mango, depending on cultivar and climatic conditions". The present observation revealed that variety Amrapali required 2 to 7 weeks while Dashehari and Kesar required 3 to 6 weeks for completion of shoot development (311–319).

The total time required for completion of vegetative flush, starting from leaf bud swelling (011) to completion of shoot development (319) was 40 to 105 days in variety Amrapali, 55 to 100 days in Dashehari and 48 to 105 days in Kesar. It was noted that the time required for the transition from the beginning of leaf bud swelling (011) to the end of leaf bud swelling (013) was the maximum (12–25 days in Amrapali, 17–25 days in Dashehari and16-25 days in Kesar) (Figs 3,4 and 5) compared to the transition period of other phenophases. Similar phenological observations were carried out in the mango cultivar Totapuri by Rajan *et al.* (2011) at five diverse locations in India and it was noted that slow and rapid growth periods during a year could be detected by using this scale. Phenological studies using the extended BBCH scale were also conducted on fruit crops like guava by Salazar *et al.* (2006), on lychee by Wei *et al.* (2013), on *Annona squamosa* by Liu *et al.* (2015) and on jackfruit by Kishore (2018).

Certain limitations of the scale were observed while recording shoot development stages. Stage 311 which marks the "beginning of shoot growth with axes of developing

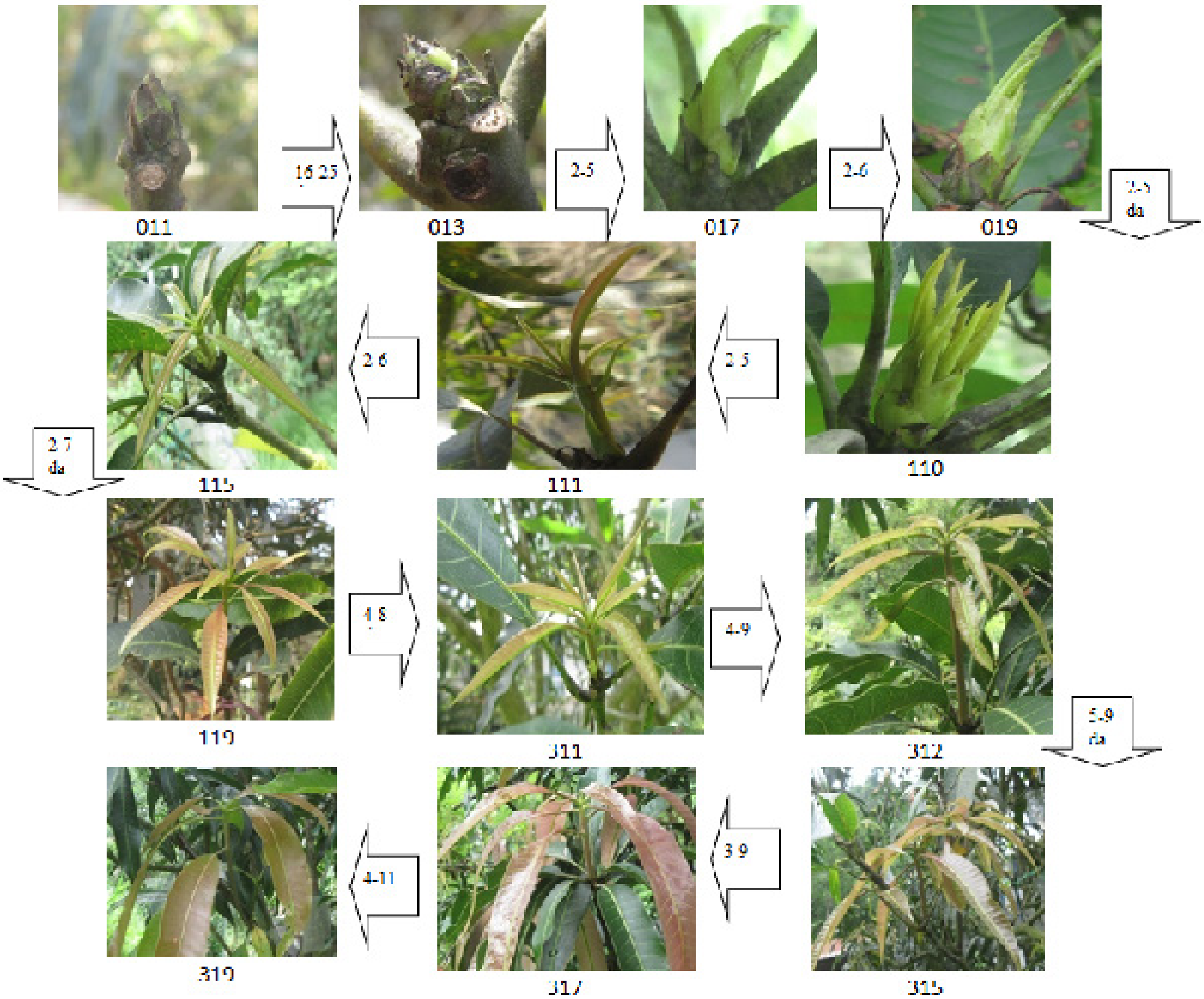

Figure 5: Time required for transition of phenophases of vegetative growth in mango variety Kesar. (Days shown in arrows are pooled values of 2 years observations)

shoots visible" is distinctly identifiable, but stages 312 to 319 where percentages of shoot length are assigned are difficult to predict precisely. These limitations were pointed out by Rajan *et al*. (2011) also. However, the percentage growth of shoots under observation was assessed relating to the lengths of other fully developed shoots on the tree. Despite its limitations, the extended BBCH scale can help mango growers enhance productivity through better and more effective cultural management practices.

A close observation on the phenology of vegetative growth can help in studying the exact stage of vegetative growth when pests attack or diseases occur. This information can keep the growers alert and help in preparing for prophylactic measures in advance. The data on the time required for transition from one phenophase to the next (Figs 3–5) can help in anticipating and planning for various plant protection measures during vegetative growth. The knowledge of the periodicity of vegetative flushes in a variety of an agro-climatic condition, and the time of occurrence of different phenophases and the duration for transition of phenophases, can be of great help in deciding upon the phase and time of application of growth regulators for regulation of vegetative growth which in turn can impact flowering and fruiting in a mango variety. The effectiveness of growth regulator treatments depends on the physiological stage of growth of a plant. Such a detailed study on the phenology of vegetative growth will provide precise information for planning growth regulator treatments and help in increasing treatment efficiencies. This information can also be helpful in planning manure or fertilizer schedules for a variety in a particular agro-climatic condition which is crucial for its vegetative growth and vigor, which ultimately influences the flowering and fruiting of a variety. Hence, the phenological data obtained from the present observations can be of great help in planning and implementing various cultural operations during the vegetative growth of the varieties and help in enhancing their productivity.

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