



Growth pattern and phenological stages of peach (*Prunus persica*) under subtropics

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ABSTRACT

Peach exhibits different phenological stages throughout its vegetative period in response to environmental conditions. Fifteen different stages were identified during the annual growing cycle of low chill peach at subtropical condition. Dormancy break first started in Saharanpur Prabhat and Pant Peach-1 during last week of January. Initiation of bloom first (8–20 Feb) noticed in Flordaprince, Sharbati Surkha and Earligrande, while full bloom was first noticed in Flordaprince Pratap and Pant Peach-1 and end of flowering earliest in Pant Peach-1 (mid to end February). Fruit maturity is important character for good market price, early maturity was recorded in Sharbati, Sharbati Surkha, Flordaprince and Pratap (last week of April to May 1st week). Maximum production efficiency (4.98 fruit/cm² TCSA,) was recorded in Pratap. Fruit weight varied from 34.85–80.57 g in different cultivars. Maximum heat use efficiency (HUE) 51.87 kg/cm² TCSA degree days was registered in Pratap and Earligrande (31.82 kg/cm² TCSA degree/day/year). For successful cultivation of low chill peaches under subtropics Flordaprince, Sharbati and Sharbati Surkha selected as early maturing, Shan-e-Punjab, Earligrande and Pratap as mid maturing and Pant Peach-1 has been found as late maturing cultivars.

Key words: BBCH, General scale, Growth pattern, Phenological stages

Peach (*Prunus persica* L.) is the most important stone fruit of India, reach earliest in market, hence, fruits are sold at premium price. High chill peaches are commonly grown in India, at higher elevations of Jammu and Kashmir, Uttarakhand, Himachal Pradesh and north-eastern hills, while low chill peaches having chilling needs 75–450 h are grown in sub-mountainous region and northern plains. For success of peach in subtropics, it is imperative to know the critical stages of growth and development, for carrying out cultural practices.

Phenology model have been developed in certain fruit crops to help growers to make management decisions on the basis of crop i.e. bud break, flower initiation, fruit growth, shoot extension, increment in trunk circumference, blooming, fruit setting, fruit growth, maturity, harvesting and beginning of dormancy or pest growth rather calendar date. It is necessary to describe the growth stages of fruit crops for good crop management through BBCH scale. It has been used by various workers in different fruit crops like loquat (Martinez-Calvo *et al.* 1999), guava (Salazar *et al.*

2006), olive (Cesaraccio *et al.* 2006), peach and nectarines (Gariglio *et al.* 2009) and peach (Mounzer *et al.* 2008). Villalpando and Ruiz (1993) described term phenological stage as an interval between two different phases. Daily light accumulation requirement provide information on crop productivity as growth and development of fruit plants are dependent on temperature, ‘phenological stages’ can be monitored using heat units or growing degree days (Durner 2013).

Early maturing peach cultivars are of considerable interest for the peach fruit growth in subtropics. Regulated deficit irrigation (RDI) is alternative irrigation module over traditional irrigation approach; it is used to reduce water application during certain period, without affecting the productivity at proper phenological stages. The objective of the present study was to describe the growth pattern as well as phenological stages of peach cultivars growing under subtropical region using BBCH code for identifying the critical stages of input application.

MATERIALS AND METHODS

The present experiment was carried out on 3 years old peach orchard during 2017–18 at experimental block of ICAR-CISH, Lucknow, which is located, on 26° 54' N longitude 80°45' E latitude and an altitude of 127 m amsl. The average annual rainfall is 950 mm, with extreme hot in summer and cold and frost in winter. The soil is mixed

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hyperthermic family of typical with sandy loam texture, free of stone and deep with 0.46% organic matter content. Eight peach varieties namely Flordaprince, Pant Peach-1, Earlygrande, Sharbati, Saharanpur Prabhat, Sharbati Surkha, Shan-e-Punjab and Pratap were grafted on seedling peach rootstock and planted in square system at $3\text{ m} \times 3\text{ m}$ distance. Five healthy trees in the middle (leaving outer trees as guard row) were randomly selected in each variety and two branches from each tree were tagged for recording the observations. Phenological stages (in days) were calculated using 1st January as reference date. The trees under the observations were drip irrigated with four dripper's/tree having 4 LPH capacities. Irrigation was scheduled to cover 100% of the plant water requirements on the basis of estimated ET. Nutrition was applied through drip systems NPK @50-25-25 g/year age, the dose was increased up to 5 years and there after fertilizer dose were stabilized. For observations visits started from November once in fortnight, frequency of the visits increased every two weeks to every day of the week depending on how quickly the peach trees changed their phenology. The pictures were clicked at every visit for support of the results and interpretation. The main phenological stages of the peach were identified visually from bud swelling to dormancy through the BBCH general scale (Lancashire *et al.* 1991).

Heat use efficiency HUE (kg/cm^2 TCSA growing degree days⁻¹) was worked out in terms of yield efficiency as ratio of yield efficiency and accumulated heat unit. Fruit weight was recorded for 10 randomly collected fruits from tagged branches. TCSA was calculated by formulae ($\text{girth}/4\pi$) and production efficiency as fruit number/ cm^2 TCSA. Fruit maturity was estimated from the date of full bloom and worked out in days. Two years data were pooled and subjected to statistical analysis using OP stat software. Average values were worked out and presented along with standard deviation.

RESULTS AND DISCUSSION

Different phenological growth stages of the eight peach cultivars were identified according to the BBCH scale of stone fruits (Meier *et al.* 1994) and Baggiolini codes (Baggiolini 1980) and are shown in Tables 1, the photographs of the main phenological stages are also presented in Fig 1.

Phenological stages and codes

Stage 00 (Dormancy):

Leaf bud and the thicker inflorescence buds closed and covered by dark brown scales, this stage was first observed in Saharanpur Prabhat and Pant Peach -1 and was late in Shan-e-Punjab (26 ± 1.5 days), and Pratap (25.99 ± 1.2) (Table 1).

Stage - (Inflorescence emergence):

51- (Inflorescence bud swelling) : Buds closed, light brown scales visible (Fig 1), earliest bud swelling noted in Pant Peach-1 (21.7 ± 1.2), late ($28-29.3$ days) in Shan-e-Punjab (Table 1).

53- (Bud burst): Scales separated, light green, bud section visible- this was earliest observed in Pant Peach-1 and Flordaprince (27 ± 1) and late (32.3 ± 1.5 days) in Earligrande.

54- (Inflorescence enclosed in light green scales): Flordaprince and Pant Peach-1 exhibited stage 54 earliest and late in Earligrande (Table 1).

55- (Single flower bud visible (still closed) born on short stalks): Green scales slightly open single flower bud visible earliest in Sharbati, and was late (39 ± 2.3 days) in Pratap (Table 1).

59- (Most flowers with petal forming as hollow ball): This stage was first appeared in Sharbati, (32 ± 3 days), late (45 ± 0.98 days) in Pratap (Table 1).

60- (First flower open): Earliest flower opening was observed in Flordaprince (36 ± 1.8 days) and was late in Shan-e- Punjab (Table 1).

65- (Full bloom; 50% flower open): Earliest full bloom (48 ± 1.3 days) was recorded in Flordaprince, and late in Saharanpur Prabhat (60 ± 1 days) (Table 1).

67: (Flower fading): Majority of flowers petal fallen; flower fading started first in Pant Peach-1 (50 ± 1.5 days) and was late (60 ± 1.3 days) in Pratap.

69- (End of flowering): All petals fallen- Pant Peach-1 exhibited earliest flowering end (53 ± 1.1 days) while it was late in Pratap (60.7 ± 0.6 days).

71- (Ovary growing, fruit fall after flowering): Earliest fruit fall and ovary growing were noted in Saharanpur Prabhat (56 ± 1.8 days).

72- (Green ovary surrounded by drying sepal crown,

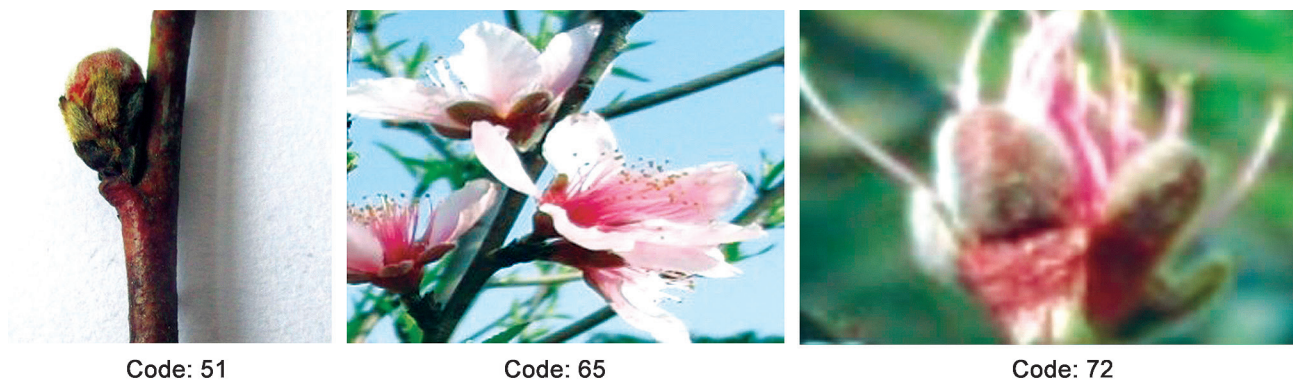


Fig 1 Important phenological growth stages of peach cultivars according to BBCH scale.

Table 1 Phenological stages of peach cultivars under sub-tropics

Phenological stages	BBCH General Scale	Earli-grande	Shane-e-Punjab	Pratap	Saharanpur Prabhat	Sharbati Surkha	Sharbati	Pant Peach-1	Florda prince
Dormancy breaking (winter bud stage)	00	22 ± 0.77	26.3 ± 1.5	25.99 ± 1.2	21 ± 1.0	25 ± 0.88	22.3 ± 0.99	19 ± 0.99	21 ± 1.0
Inflorescence Bud Swelling: buds closed light brown scales visible	51	28 ± 1	29.3 ± 1.5	29 ± 1	27 ± 1.0	27 ± 1.2	25 ± 1.3	21.7 ± 1.2	24.7 ± 1.3
Bud burst: scales separated, light green bud section visible	53	32.3 ± 1.5	31.3 ± 1.5	31 ± 1.2	31.7 ± 1.5	31.7 ± 2.1	31.3 ± 1.5	27 ± 1	27 ± 1
Inflorescence enclosed by light green scales, if such scales are formed (not all cultivar)	54	32.7 ± 2.1	30.3 ± 1.5	30.3 ± 1.5	32 ± 1.0	32.3 ± 0.6	31 ± 1.1	29 ± .98	29 ± .95
Single flower bud visible (still closed) borne on short stalks, green scales slightly open	55	34 ± 1.3	32.3 ± 1.5	39 ± 1.3	34 ± 1.0	33.7 ± 0.6	32 ± 2	32 ± 1.3	32 ± 1.1
Most flower with petal forming a hollow ball	59	38 ± 0.95	39.3 ± 1.	45 ± 0.98	37 ± .97	35.3 ± 1.5	35 ± 1.1	34 ± 1.1	35 ± 1.09
First flower open	60	42 ± 2.1	50.3 ± 1.5	50 ± 1.6	41 ± 1.2	37 ± 1.0	40 ± 2.1	39 ± 2.2	36 ± 1.8
About 50% flower open	65	52 ± 1.9	54 ± 2	51 ± 1.2	60 ± 1	58 ± 1.0	52.7 ± 1.5	54 ± 1.3	48 ± 1.2
Flower fading: majority of petals fallen	67	53 ± 1.7	57 ± 2	60 ± 1.3	60.3 ± 1.5	59 ± 1.3	55 ± 1.4	50 ± 1.5	55 ± 1.3
End of flowering: all petals fallen	69	56 ± 1.6	59 ± 1.8	60.7 ± 0.6	55 ± 1	60 ± 1.4	60 ± 1.2	53 ± 1.1	56 ± 1.2
Ovary growing; fruit fall after flowering	71	58 ± 2	64 ± 2	63 ± 1.5	56 ± 1.8	63 ± 1	60.7 ± 1.2	56 ± 1.3	57 ± 1.4
Green ovary surrounded by dying sepal crown, sepals beginning to fall	72	61 ± 1	68 ± 1.6	66 ± 1	58 ± 1	67 ± 1.1	66 ± 1.3	61 ± 1.4	64 ± 1.2
Fruit about 80% of final size	78	84 ± 1.53	87 ± 1.1	86 ± 1.2	87 ± 1.6	95 ± 1.3	87 ± 1.2	91 ± 1.6	82 ± 1.2
Beginning of fruit colouring	81	94 ± 1.8	96 ± 0.98	93 ± 2.0	97 ± 1.7	92 ± 1.8	93 ± 2.1	98 ± 1.5	88 ± 1.5
Fruit ripe for consumption: fruit have typical taste and firmness	89	103.3 ± 1.5	101 ± 1.5	99 ± 2.1	102 ± 2.1	96 ± 2.1	98 ± 2	109 ± 1.5	94 ± 2.3

sepals beginning to fall): Earliest sepals drying (58±1 days) was recorded in Saharanpur Prabhat and late (66±1-68±1.6 days) (Fig 1, Table 1).

78- (Fruit growth about 80%): This stage was first observed in Flordaprince (82±1.2 days) and Earligrande (84±1.53 days) and late in Pant Peach-1 (95±1.6 days) (Table 1).

81- (Beginning of fruit colouring): Colour break is the reliable maturity indicator, earliest colour break was noted in Flordaprince (88±1.5 days) and Sharbati Surkha (92±1.8 days) and late in Pant Peach-1 (98±1.5 days) (Table 1).

89- (Fruit ripe for consumption fruit have typical taste and firmness): Earliest fruit ripening was started in Flordaprince (94±2.3 days) days and late (109±1.5 days)

in Pant Peach-1 (Table 1).

Earliest maturity from date of full bloom was noted in Sharbati (62 DAFB), Sharbati Surkha (65 DAFB) and Flordaprince (69 DAFB) and late (89 DAFB) in Pant Peach-1 (Table 2). Maximum production efficiency (4.98 fruits/cm² TCSA) was noted in Pratap and Pant Peach-1 (4.31 fruits/ cm² TCSA) and minimum (0.89 fruits/cm² TCSA) in Sharbati Surkha (Table 2). Fruit weight is an important quality parameter for peach marketing, it varied 34.85–80.57 g among different cultivars and maximum fruit weight (80.57 g) was recorded in Pant-Peach-1 and minimum (34.85 g) in Sharbati Surkha (Table 3). Maximum yield (53.33 kg/tree) was noted in Pant Peach-1 and minimum (2.75 kg/tree) in Sharbati Surkha. The variety which had higher yield also

Table 2 Flowering, fruit maturity pattern and yield attributes of peach cultivars

Variety	Initiation of bloom	Full bloom	Start of maturity	Fruit weight (g)	Production efficiency (Fruit no/cm ² TCSA)	Yield (kg/tree)	Maturity day after full bloom (Days)	HUE (kg/cm ² TCSA/degree day)
Earligande	10-20 Feb	20-28 Feb	5-7 May	65.39	1.74	22.50	76	31.82
Shan-e-Punjab	15-22 Feb	20 Feb -01 March	2-5 May	59.85	1.93	18.30	73	27.53
Pratap	20-23 Feb	18-28 Feb	1-5 May	73.52	4.98	53.33	65	51.87
Saharanpur Prabhat	20-25 Feb	24-28 Feb	1-5 May	48.00	2.31	3.26	79	31.75
Sarbati Surkha	08-20 Feb	22-28 Feb	29 April-1 May	34.85	0.89	2.75	64	0.79
Sarbati	10-20 Feb	22-28 Feb	28 April -1 May	45.43	3.98	18.68	62	23.82
Pant Peach-1	10-22 Feb	20 Feb -3 March	12-20 May	80.57	4.31	22.40	89	25.97
Flordaprince	08-20 Feb	18-28 Feb	25 April-1 May	64.71	3.99	15.74	69	13.71
CV (%)	-	-	-	5.28	30.71	23.88	5.84	21.69
LSD (P=0.05)	-	-	-	4.90	0.73	2.28	8.84	2.02

exhibited greater Heat Use efficiency (HUE). Maximum HUE noted in Pratap and Earligande (51.87 and 31.82 kg/cm² TCSA/degree/day, respectively) and low HUE (2.75kg/cm² TCSA/degree/day) in Sharbati Surkha (Table 2).

Growth pattern: End of dormancy, bud visible, initiations of bloom and full bloom showed considerable variations in different years (2017–18). During 2017, phenophase occurred 5–7 days earlier than 2018. The climatic data showed that minimum and maximum temperature were comparatively higher in November–December 2016 to March–April 2017, higher temperature advanced the dormancy breaking and other phenophases. Harvest maturity recorded from the date after full bloom and earliest maturity noted in Sharbati (60 DAFB) and Flordaprince (69 DAFB) from 20th April to 4th May in both the years. The seasonal variations in the growth pattern of peach cultivars have been depicted in Fig 1. Peach exhibited double sigmoid growth curve (Chalmers and van den Ende 1975, 1977). Dormancy breaking among all the low chilling peach cultivars lasts 19 to 27 days. Days requires for fruit maturity are controlled by genetic and environmental interactions. Early maturing peach cultivars have single peak while late maturity has two peaks (double sigmoid curve) (Nicolas *et al.* 2006). Higher HUE in some of the peach cultivars may be attributed to the genetic constituents of the varieties. HUE is positively correlated to the production efficiency as well as yield/tree. Higher yield in early maturing peach cultivars, attributed to comparatively moderate temperature. This is attributed to the increase in dry matter content, resulted by proportionate absorption of heat unit. These results are in agreement with the findings of Gariglio *et al.* (2009) in peaches and nectarines in wheat (Tripathi *et al.* 2004).

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varieties exhibited higher fruit set as low chilling cultivars usually had tendency of higher fruit set. These results are in agreement with the findings of Gariglio *et al.* (2009), who reported low chilling peach had 65% more fruit set than high chilling varieties. Low chilling peach cultivars showed better adaptation in the northern plains of subtropics as these cultivars showed extended period of blooming which had a higher opportunity for fruit set (Perez 2004). In northern plains of subtropics late blooming varieties exhibited tendency of low fruit yield due to relatively higher temperature and dry winds during bloom, post fruit set desiccation, drying of pollen grains and excessive dropping of fruits (Perez 2004) lead poor yield and quality. Yield attributing parameters differs among varieties and time of harvesting. Early and mid-maturing cultivars had greater accumulation of the biomass content due to higher and efficient partitioning of the photo-synthates for economic yield. These results are in agreement with the findings of Perez (2004) and Gariglio *et al.* (2009). Phenological stages of peach can be useful for scheduling cultural operations in north India plains to protect them from hot winds and to produce more quality fruits.

It can be concluded that in northern plains of India, low chilling peach cultivars with 75–450 CU can attain sufficient growth, fruiting and showed better adaptations. Initiation of flowering was noted between first week of Feb to mid to last week of Feb and full bloom recorded mid of February to first week of March among the cultivars. During these events weather is clear and chances of frost and break out of diseases and pests are minimal unlike hilly area. Heat use efficiency was high in Pratap, Earligande, Saharanpur Prabhat and Shan-e-Punjab. Horticultural maturity was noticed between 25th April to 20th May among the peach

cultivars in subtropics. Flordaprince, Sharbati and Sharbati Surkha are categorized as early maturing, Shan-e-Punjab, Earligrande and Pratap as mid maturing and Pant Peach-1 as late maturing cultivars under subtropics. Attractive and appealing fruits were recorded in Flordaprince, Sharbati, Shan-e-Punjab and Pratap cultivars.

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