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Thermal time and phenology of citrus in semi-arid conditions

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Abstract
The experiment was conducted at Citrus orchard, Department of Horticulture, Chaudhary Charan singh Haryana Agricultural University Hisar. Fully grown twelve year old trees properly maintained of uniform size and vigour, free from disease and pest, of three *Citrus* groups with two cultivars in each were used in study. Spring flush was taken in all the six varieties of three groups; Sweet orange Mandarin hybrids and Grapefruit. All citrus species and their respective cultivars behaved different from each other in the same environments. The bud break was observed earliest in sweet orange that took after 13 days of during 2014 and. latest during 2015 after 14 and 10 days of buds initiation (Jaffa and Pine apple) as compared to other citrus species. The floral development between sweet orange cultivars was faster in Pine apple as compared to Jaffa. Flowering end was later during 2014 in all the citrus cultivars bercause of low temperatures prevailed during February, 2014 as compared to February 2015. The slope of linear regression line between rate of floral development and heat units accumulated indicates that rate of floral development per unit degree day was -0.002 in citrus cultivars.

Keywords: citrus, bud break, bud initiation, heat units, flowering, rate of development

1. Introduction
Citrus is believed to have originated in the part of Southeast Asia bordered by Northeastern India, Myanmar and the Yunnan province of China. Citrus flowering is a complex phenological process influenced by a number of interacting factors. Under north Indian conditions, the temperature goes down substantially during winter months and major bloom in all citrus species occurs almost during early spring (February-March) when the atmospheric temperature starts rising after the cold winter and soil moisture conditions are suitable. As low temperature cause bud inactive and release of stress by higher temperature triggers the beginning of reproductive growth. Even the rate of flower bud development also temperature dependent phenomena. The main temperature ranges for the growth of citrus by Mendel (1969) [5] as minimum 12.5-13.0, optimum 23-34 ºC and maximum (limiting growth) 37-39 ºC. Thus in central India month of March is found crucial for citrus growth. In this period minimum temperature remains favourable for growth, but maximum exceeds beyond required limit and cause heavy drop of small fruit let and leads to drastic reduction in yield. Keeping the above in view, an attempt was made to study phenology and thermal behaviour of different citrus species and their cultivars under semi-arid conditions of Hisar.

Material and Methods
The experiment was conducted at Citrus orchard, Department of Horticulture, Chaudhary Charan singh Haryana Agricultural University Hisar. Fully grown twelve year old trees properly maintained of uniform size and vigour, free from disease and pest, of three *Citrus* groups with two cultivars in each were used in study. Spring flush was taken in all the six varieties of three groups:

1. Sweet orange (C*itrus sinensis* (L.) Osbeck) *cv.* Jaffa and Pineapple
2. Mandarin hybrids- Pearl Tangelo *(Citrus reticulata* Blanco *x Citrus paradisi* Macf.) and Kinnow *(Citrus nobilis* Lour. x *Citrus deliciosa* Tenore)
3. Grapefruit (C*itrus paradisi* Macf.) *cv.* Duncan and Ruby Red

Five trees of each of two cultivars taken from every species mentioned above, three citrus groups were selected for investigation. Thus, all the six cultivars were replicated five times using single plant as a unit arranged in Randomized Block Design (RBD). The recommended standard package of cultural practices and plant protection measures for citrus crop were followed uniformly for all the 30 trees. On each replicated tree, randomly five shoot were tagged in all directions representing North, West, East and South and middle portion of the tree canopy for further recording following observations.

Time of bud initiation
From the day one, the bud appeared on the shoot the date of bud initiation was recorded and used to count the period taken for morphological and developmental changes occurring subsequently.

Time of bud break
The day on which the developing buds exhibited to swell, green tips and first leaf tissue appearance the date was recorded. The period from the date of bud initiation to the date of bud break was counted as the time taken in days for bud break. Accordingly, heat units required or consumed during this period were worked out and accumulated from start to end date of a phenophase for the individual citrus cultivars/hybrids. Accumulated heat units above the physiological threshold for citrus trees (12.5 ºC) are the decisive factors in the growth rate (Mendel 1969) [5].

Time of flowering
Day and date of the opening of first flower as the initiation of flowering; while more than 50% flowers opened as full bloom, and when more than 80% flowers opened on selected trees, the end of flowering was recorded. The dates of the first and last flower opening were recorded and then the duration of flowering was determined by counting of days from the date of first flower opening to the date of the last flower opening.

Heat units
Daily meteorological data of both seasons were taken from Agro-meterological observatory CCS HAU, Hisar and Heat unit (HU) were calculated as per method adopted by Mendel (1969) [5].

$$HU\ (^{o}Cd) = \sum_{a}^{b} [(Tmax+Tmin)/2 - Tb]$$

Where,
Tmax and Tmin = Maximum and minimum temperatures(ºC)
a & b = Starting date to ending date of a phenophase
Tb = Base temperature (12.5 ºC for citrus species).

Rate of floral development
It is defined as inverse of the days taken to complete the flowering in citrus cultivars. It is calculated as under:
Rate of floral development (RFD) = 1/days taken
Relationship of rate of development with heat units accumulated was quantified by pooling the data of all the citrus cultivars using regression analysis.

Result and Discussion
In citrus the rate of vegetative development is accelerated more by warmer climatic conditions than the cooler one. The cardinal temperatures of citrus species reported as minimum of 12.5-13 ºC, optimum of 23-34 ºC and the maximum of 37-39 ºC fundamentally, in citrus species during the growing period, three phases of growth and fruiting occur in India. The first stage being from Feb-May as flowering, fruit set and fruit growth phase, the second stage extends from June-Sept having fruit growth and development period and the third stage begins from October, stretching up to December end and progressing towards fruit maturity and ripening. It was observed that spring flush (March- April in northern hemisphere) usually being far more intense affects more growing points than the summer flush. Spring flush contains both vegetative and reproductive shoots. As the trees get older, the spring flush mainly comprises of short reproductive shoots (leafy/non-leafy inflorescences).

Time of bud initiation to end of flowering
The days taken for floral phenology (bud initiation, bud break, flower initiation, full bloom and end flowering) of different citrus cultivars are presented in Table 1. The bud break was observed earliest during 2014 in sweet orange that took 13 days and latest during 2015 that took 14 and 10 days after bud initiation (Jaffa and Pine apple) as compared to other citrus species. Bud break and full bloom was faster during 2015 as compared to 2014. This was due to availability of more growing degree per day during these periods in 2015. Days for end of flowering were more during 2014 in all the citrus cultivars of three citrus species. The floral development in sweet orange cultivars was faster in Pine apple as compared to Jaffa. Flowering end was later during 2014 in all the citrus cultivars berceuse of low temperatures prevailed during February, 2014 as compared to February 2015. End of flowering also found dependent on fulfilment of heat units requirement. As it was also in harmony with Poerwanto and Inoue (1990) [7] low air temperature resulted in long flowering durations.
Bud break in hybrid mandarins and grapefruit took less days during second season as compared to first season. Mandrin hybrid Kinnow took less days for bud break in comparison to Pearl Tangelo in both the seasons.. It was observed that low temperature during February resulted in delayed bud initiation and bud break during season 2014. These findings are supported by findings of Srivastava *et al.,* 2000 [12] and Rikhande *et al.,* 2013 [9]. Grape fruit cultivar floral development was faster in ruby red as compared to Duncan. Full bloom duration varied in the both seasons in all the citrus species. This might because of thermal variability during this period in both the seasons. Thakur *et al.* (2008) [13] concluded that early maturing varieties required less heat units than the late maturing varieties.

Heat units
The heat units were accumulated from bud initiation to end of flowering for different phenophases of citrus spices and mean vales of both seasons are presented in table 2. Perusal of data given in Table 1 showed that thermal time required for bud initiation was more in sweet orange cultivar Jaffa (32.5 ºCd)as compared to pine apple(20.8 ºCd). While thermal time taken for flowering initiation, full bloom and end of flowering was more in Pine apple as compared to Jaffa. It might be due to their different genetics within same citrus group. High day time temperatures shorten the bud development time and advanced the date of flowering. These results were in conformity with Lovatt *et al.,* 1984 [4] and Srivastava *et al.,* 2000 [12].
Mandrin hybrid Pearl tangelo took less thermal time to complete flowering as compared to Kinnow. Ruby red took 13.8 ºCd less thermal time as compared to grapefruit cultivar Duncan for end of flowering. Among the citrus cultivars Pine apple taken minimum thermal time for bud break and followed by Pearl tangelo, Ruby red, Duncan, Jaffa and Kinnow. However the thermal time trend was not same for end of flowering i.e. Ruby red taken minimum thermal time followed by Duncan, Jaffa, Pine apple, Pearl tangelo, and Kinnow. This might be because of their differential floral biology. These results were in conformity with Choudhari and Rane (1976) [1] who observed that delay in peak bloom period of some cultivars is attributed to their requirements of slightly

warm weather for emergence of vegetative flush. The duration of flowering showed variation in cultivar phenol-thermal response and dependent on heat unit accumulation. As heat unit requirement was completed, cultivars shifted into next stage provided no limitation in other factors. Nebauer *et al*. (2006) [6] findings also support the results. These results are also in harmony with several workers *viz.* Lord and Eckard, 1985; Poerwanto and Inoue, 1990 [7] Guardiola, 1997 [2] suggested that bud differentiation processes of citrus was under the influence of temperature.

Relationship of floral development and heat units

The rate floral (bud initiation, flowering initiation, full bloom and end of flowering) development of citrus species was related with accumulated heat units from bud initiation and the regression equation of respective relationship along with R^2 are given in the figure 1. Rate of development was negatively related with accumulated heat units. The slope value indicates that rate of floral development per degree day was -0.002, in citrus species (Jaffa, Pine apple, Pearl tangelo, Kinnow, Duncan, and Ruby red) citrus cultivars. Lovatt *et al.* (1984) [4] reported the rate flower development was positively correlated with degree days. Poerwanto and Inoue (1990) [7] observed flower sprouting within seven days at 30/30 ºC, 11 days at 30/15 ºC, 21 days at 15/30 ºC, and 33 days at 15/15 ºC, respectively on Satsuma mandarin *(Citrus unshiu* Marc. cv. Okitsu Wase). The variation in the heat unit's requirement with the variation in date of maturity was also reported in Ber (Singh *et al.,* 1998b) [11]; Mango (Shinde *et al.,* 2001) [10] and Litchi (Rai *et al.,* 2002) [8].

Table 1: Days taken from bud initiation to bud break, flower initiation and full bloom in different citrus species and cultivars during 2014 and 2015

Citrus species	Cultivars	Bud break		Flower initiation		Full bloom		End of flowering	
		2014	2015	2014	2015	2014	2015	2014	2015
Sweet orange (*Citrus sinensis*)	Jaffa	13	14	20	8	7	7	13	18
	Pineapple	13	10	26	23	3	5	7	9
Mandarin hybrids	Pearl Tangelo	14	8	17	22	5	5	9	10
	Kinnow	11	7	7	8	5	8	10	12
Grapefruit (*Citrus paradisi*)	Duncan	20	7	11	16	3	5	7	7
	Ruby Red	17	4	12	19	4	4	5	5
SEm ±		0.78	0.53	1.05	0.81	0.35	0.49	0.98	1.07
CD at 5%		2.12	1.44	2.85	2.20	0.95	1.33	2.66	2.90

Table 2: Heat units consumed from bud initiation to end of flowering in different citrus species and cultivars during 2014 and 2015(Mean of both seasons)

Citrus species	Cultivars	Bud break	Flower initiation	Full Bloom	End of flowering
Sweet orange (*Citrus sinensis*)	Jaffa	32.3	78.9	104.9	189.3
	Pineapple	20.8	128.0	145.5	208.6
Mandarin hybrids	Pearl Tangelo	21.2	113.6	140.0	208.7
	Kinnow	41.8	83.7	121.9	216.7
Grapefruit (*Citrus paradisi*)	Duncan	29.6	97.3	111.8	162.5
	Ruby Red	21.9	107.3	113.3	148.3
SEm ±		1.79	3.14	4.10	5.9
CD at 5%		4.85	8.52	11.12	16.00

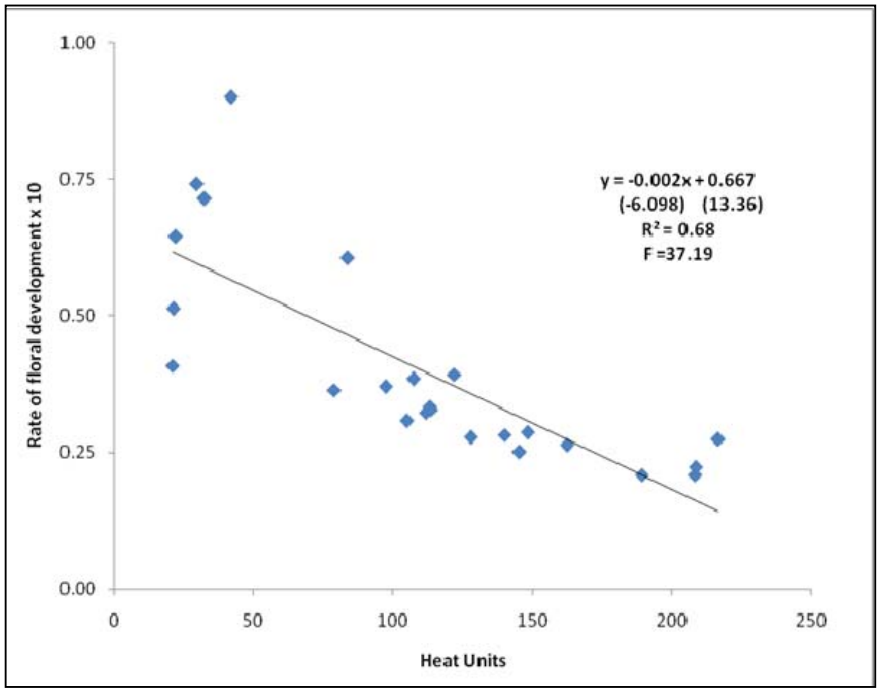

Fig 1: Relation of floral development (RFD)with heat units(HU, ºCd) accumulation in citrus species. (Values in parenthesis are 't' values)

Conclusion

It is concluded that Kinow cultivars took maximum and ruby red took minimum thermal time from bud initiation to complete flowering. Rate of development of flower was negatively related with heat units accumulated in all the citrus cultivars.

References

1. Choudhary KG, Rane SD. Floral biology of few important citrus cultivars. J Maharashtra Agricultural Universities. 1976; 1(2-6):85-89.
2. Guardiola JL. Overview of flower bud induction, flowering and fruit set, In: Futch, S.H. and Kender, W.K. (eds.) Citrus Flowering and Fruit Short Course. Citrus Research Education Center Lake Alferd, Florida. 1997, 98-99.
3. Lord EM, Eckard KJ. Shoot development in *Citrus sinensis* (L.) Osbeck (Washington Navel orange). Floral and inflorescence ontogeny. Bot. Gazette. 1985; 146:320-326.
4. Lovatt CJ, Streeter SM, Minter SM, O'Connell NV, Flaherty DL, Freeman MW *et al*. Phenology of flowering in *Citrus sinensis* (L.) Osbeck, (Washington navel orange). Proc. Intern. Soc. Citriculture. 1984; 1:186-190.
5. Mendel K. Proc. 1st Int. Citrus Symp. Riverside. 1969; 1:259-265.
6. Nebauer SG, Avila C, Garcia Luis A, Guardiola JL. Seasonal variation in the competence of the buds of three cultivars from different Citrus species to flower. Trees-Structure and Function. 2006; 20(4):507-514.
7. Poerwanto R, Inoue H. Effects of air and soil temperature on flower development and morphology of Satsuma mandarin. J Hort. Sci. 1990; 65:739-745.
8. Rai M, Nath V, Das B. Heat unit summation-an index for predicting fruit maturity in litchi (*Litchi chinensis*). Ind. J Hort 2002; 59:34-38.
9. Rikande J, Mahdavi Amiri, Akhlaghi N, Shahabian Mehrdad. Determination of bud differentiation time of three various citrus varieties in-Sari, Iran. Intern. J Agric Crop Sci. 2013. 6(5):292-295.
10. Shinde AK, Burkondkar MM, Bhigarde RT, Waghmare GM, Rangwala AD, Wagh RG. Heat unit requirement for fruit maturity in mango varieties. Ind. J. Plant Physiol. 2001; 6:194-196.
11. Singh R. S. and Vashishta, Prasad R.N. Micrometerlogy of Ber (*Zizyphus maruritiana*) orchard grown under rainfed arid conditions. Ind. J. Hort. 1998, 2001; 55:97-107.
12. Srivastava AK, Singh S, Huchche AD. An analysis on citrus flowering – A review, *Agril. Rev.* 2000; 21(1):1-15.
13. Thakur A, Arora NK, Singh SP. Evaluation of Some grape varieties in arid irrigated region of North West India. Acta Hort. 2008; 785:79-83.