CHILLING AND HEAT REQUIREMENTS FOR CHERRY (*PRUNUS AVIUM L.) AND PEACH (PERSICA VULGARIS MILL.) FRUIT TREES IN BULGARIA*

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Abstract

Climate anomaly has affected the rates of chilling accumulation, which are vital for flowering and production in temperate fruit trees. As an adaptation to cold winter orchards enters a period of dormancy designed to protect cold-sensitive tissues such as shoots flowers from freezing injury. Successful release from dormancy requires a specific minimum cold temperature requirement to be met for growth to resume when the temperature warms in spring. This cold temperature is specific and referred to as the "chilling requirements".

The present study aimed to use the relationship between the state of chilling and the state of swelling of buds and flowering of cherry and peach for 10 stations in Bulgaria, during the period 2000-2015 and daily chill accumulation. The buds remain dormant until they have accumulated sufficient chilling units (CU) of cold weather. When enough chilling accumulates, the buds are ready to grow in response to warm temperatures. If there have been enough CU's, the flower and leaf buds develop normally. If the buds do not receive sufficient chilling temperatures during winter to completely release dormancy, trees will develop one or more of the physiological symptoms associated with insufficient chilling: 1) delayed folia appearing; 2) reduced the number of the fruits, and increased butonisation; 3) reduced fruits quality.

Keywords: *chilly units (CU), chilling requirements, chilling accumulations, phenology, CU models*

1. INTRODUCTION

Bulgaria is a country with a temperate climate, which is characterized by four phitoclimatic seasons. This allows the cultivation of most major fruit trees that low temperatures during the winter season. Trees from those climates evolved a period of dormancy to avoid frost damage during the cold season (Seeley,1996). This dormancy protects vegetative and fruiting buds from oncoming cold weather. These buds remain dormant until they have accumulated sufficient chilling units (CU) of cold weather. When enough chilling accumulates, the buds are ready to grow in response to warm temperatures. A chilling unit in agriculture is a metric of a plant's exposure to chilling temperatures. Chilling temperatures extend from freezing point to, depending on the model, 7°C or even 16°C. (Byrne and Bacon, 1992). Stone fruit trees of temperate climate develop next year's buds in the summer. In the autumn the buds become dormant, and the switch to proper, healthy dormancy is triggered by a certain minimum exposure to chilling temperatures. One chilling unit, in the simplest models, is equal to one hour of exposure to the chilling temperature. These units are summed up for a whole season. Advanced models assign different weights to different temperature bands. According to Fishman (1987), chilling in trees acts in two stages. The first is reversible when chilling helps to build up the precursor to dormancy, but the process can be easily reversed with a temperature rise. After the level of precursor reaches a certain threshold, dormancy becomes irreversible and will not be affected by short-term warm temperature peaks. (Southwick et al., 2003) Chilling requirements (Richardson et. al, 1974) is defined as the number of effective chilling hours needs to restore bud growth potential in spring Apples have the highest chilling requirements of all fruit trees, followed by apricots and lastly peaches. (Hall, 2001). The thermal sum needed to re-establish vegetative growth is defined as heat requirement (HR) and is assumed to be trait genotype-dependent.

The optimum temperatures for dormancy release of floral buds of deciduous fruit trees were determined to be 6-8°C in peach (Erez and Lavee, 1971) and 3,2-3,7°C in sweet cherry depending on the cultivar (Mahmood et al., 2000). Chandler et al. (1937) reported that the optimum temperatures for the peach to

be between -1°C and 0°C and between 0,5°C and 4,5°C respectively. These optimum temperatures may change as the ability of the plants to react to temperature over time changes and the deep and length of dormancy can be modified by the conditions which affect the plant while dormancy develops (Seeley, 1996). Unsatisfied chilling needs can result in delayed foliation, severe yield, and reduced fruit quality. There is a need for a method to estimate accurately the chilling requirement of a cultivar. This is especially important in those areas where the potential of chill accumulation in winter is low and for those crops, such as sweet cherry, which generally have a high chilling requirement. Several studies showed that ratios between winter chill estimates calculated with different models differ strongly under varying environmental contexts, as well as between years and sites within growing regions (Luedeling et al., 2011)

Most of the chill models were developed using stone fruit to quantify the winter chill required for dormancy completion.

The Chilling Hours model was developed in the early fifties of the 20th century, and it has been widely used up to now due to its simplicity and easy comprehension and calculation. This model establishes that a Chilling Hour (CH) corresponds to an hour at a temperature between 0 and 7,2°C since this range of temperatures is considered to affect dormancy completion. While temperatures below 0˚C are assumed not contributing due to at such low temperatures biological processes were considered slowed or not occurring, temperatures over 7,2°C were considered not low enough to affect dormancy completion. Weinberger (1950). However, this model did not consider the negative effect of high winter temperatures on chill accumulation, especially in a warm climate. This deficiency was overcome by the Utah model for peach (Richardson et. al, 1974) and the Dynamic Model (Erez et al., 1990; Fishman et al.,1987). The Utah model bases on the quantification of Chilling Units (CU) and establishes different ranges of temperatures with a different contributions to dormancy completion. A chilling unit corresponds to one hour under temperatures between 2.5-9°C, a range that is considered the most effective temperatures on dormancy completion. Other ranges of temperatures are considered to have half (1,5-2,4 °C and 9,2-12,4◦C), null (<1,4 °C and 12,5-15,9°C) or negative (>16°C) contribution to dormancy Thus, positive and negative hourly values are accumulated at different rates, between -1 and 1, for each hourly temperature. Although this model provides good results in cool temperate climates, it is not accurate in areas with high winter day temperatures (over 20°C) as it yields a large quantity of negative chill (Erez et al., 1990; Shaltout and Unrath, 1983). A modification of the Utah model, the Positive Utah Model, has come up with better results in sub-tropical and tropical mild winter conditions (Linsley-Noakes et al., 1994). It assumed that previously accumulated chilling cannot be negated by the influence of high temperatures, but equal to zero for every rise in temperature above 12,5°C and below 1,5°C. **The Dynamic model**, dated back from the 1980s (Fishman et al., 1987), is based on a series of experiments that evaluated the effect of different series of temperatures on dormancy release (Erez, 1987). This model proposed the accumulation of an intermediate product promoted by cold temperatures that can be reversed by warm temperatures (first step). Once this intermediate product has reached a certain level, the chill portions are permanently fixed and are considered not affected by warm temperatures (Fishman et al., 1987). The model is based on a possible biological process in which a thermally unstable precursor would lead to the accumulation of a factor in the buds. This process would follow the Arrhenius law that fits the mathematical relationship between temperature and the rate of a chemical reaction. The model has given better results in warm temperate and subtropical climates. The majority of studies have found the Dynamic model to be relatively accurate in different climates as compared to other commonly used Chilling Hours (CH) approaches. An alternative chilling model was proposed by Lantin (1973; 1977), based on an exponential “cold action” function (Bidabe, 1967), and summed over the period of time:

$$Af = Q10\text{-}tm/10 + Q10\text{-}tM/10, \text{ where}$$

Af = daily chill units accumulated (subsequently referred to as ‘Lantin’ units), tm, tM = minimum, maximum daily temperatures (°C), Q10 = temperature coefficient (expressed as the ratio of the effect at temperature T°C to the effect at - 10°C). The model works with daily temperature values.

This paper **aims** to obtain the relationship between the state of chilling and the state of "swelling of buds" and "flowering" of Cherry (*Prunus avium* L. and Peach (*Persica vulgaris* Mill. for 11 stations in Bulgaria, during the period 2000-2015 for daily and hour's chilly units.

Two of the already developed chilling models "Lantin model", based on an exponential "cold action" (Lantin 1973;1977) and "Utah" (Richardson et. al, 1974; Anderson et al,1986) were calibrated and tested with our monthly and hourly data.

2. MATERIALS AND METHODS

2.1. Materials

Cherry (*Prunus avium* L.) and peach (*Persica vulgaris* Mill.) plants are traditionally orchards in Bulgaria. The optimum results for the growth are got only in separate regions, where the meteorological conditions are most suitable for their growth and development. Data for this investigation were collected from agrometeorological, climatic archive and database of the National Institute of Hydrology and Meteorology (NIMH). Long-term 2000-2015 daily, monthly and hourly meteorological data have been processed. To characterize the chilly requirements during the winter period from the database are taken hourly values of air temperature for the period December - March for 2000 -2015, measured every 3 hours in 2, 5, 8, 11, 14, 17, 20, and 23 hours. Dates on the phenological development and more precisely the dates of "buds swelling" and "flowering " for cherry and peach trees during the period of 2000-2015 are presented for 11 meteorological stations. Used stations were grouped by the similarity of agrometeorological conditions. The dates of steady transitions of temperatures and average dates occurrence of phenological stages -" buds swelling" and "flowering " are present as time series of days which starting date 1th January, i.e. Julian days. For a day of appearing of given stages is accepted the first day after registration of mass arriving of this stages i.e. when it is observed on the more than 75 % of the trees. Traditional areas for growing orchards include areas from two climatic zones end four sub-regions, according to the climatic zoning of Bulgaria (Stanev et al., 1959). The stations of investigation are located in Mmoderately continental sub-region included the Northern climate region of the Danube plain - Kneja, Ruse, and Silistra. That area is characterized by the coldest winter. Here the coldest temperature in January is between -1,5 °C and -2,5 °C. The lowest maximum temperatures in winter usually reach -20 °C -2 5°C. Winter is assessed as by relatively high severity, which is emphasized by the frequent frosty days, as well as a large number of days with relatively low minimum temperatures. Middle climatic region of the Danube plain - Razgrad and Lovech.The winter temperature conditions in this region do not differ significantly from those in the northern region, however, some peculiarities are noticed, which are due to the relative proximity of Stara Planina. The characteristic peculiarity is the more frequent manifestation of foehn wind. Therefore, here the average of the absolute maximum temperatures for January is around 10-12 °C, while in the northern region they are 8-9°C. The Eastern region of the Danube plain covers the eastern part of Dobrudja - Dobrich. The continental nature of the climate in these arias is temperate. It is characterized by a relatively mild winter. The winter frosts are not so great, but a characteristic feature of the region is the strong east winds, especially in the northern part of the region. Mild winter is also reflected in the distribution of hard precipitation. In this area, only 40-45% of the precipitation is from snow. Transitional continental sub-region included the Climatic region of Eastern Central Bulgaria - Sliven and Chirpan. This area covers most of the lowlands of Maritsa and Tundzha. It is assessed by a relatively mild winter, with an average temperature of about 0 °C in January, and is characterized by relatively more frequent warming under the influence of Mediterranean cyclones. Kyustendil-Blagoevgrad climatic region - Blagoevgrad and Kyustendil areas. This region covers the places from the northern half of the Struma Valley, including Kyustendil and Blagoevgrad fields. They are characterized by a significantly milder winter, as the Blagoevgrad field is lower and with a southern location. The average January temperature in the region is from -1 to 1 °C, and the coldest in the Kyustendil field. The snow cover is significantly more unstable compared to Sofia Field. The region is characterized by relatively late and intense spring frosts. This is especially pronounced in the Kyustendil field. The continental Mediterranean region includes the Black Sea climate sub-region - Shabla and Burgas. In winter and autumn, the sea air is significantly warmed. The

Black Sea part is emerging as one of the warmest parts of the country. The January temperature in its northern part is from 0 to 1.5 °C for Shabla, and in the South about 3 °C for Burgas.

Georgieva and Kazandjiev (2013) established that during the winter dormancy are two areas in which more than 50% of the period temperatures remain below -15°C for more than three days in the Central part of the Dunabian Plain and the Central part of the Thracian lowland. Analysis of cases with temperatures below -15°C, compared with the availability and snow cover depth shows that the largest percentage of days with snow cover less than 10 cm in Razgrad (48%), lowest in Buzovets (14%) and between 2-16% of cases there is no snow cover. The greatest risk of damage they established in Northeastern Bulgaria and the North-Western region.

2.2. Methods

All-time series was tested for homogeneity and was controlled statistical parameters - average, standard deviation, and variation coefficient by applying standard procedures from the package "STATISTICA. For all 18 agrometeorological stations are received the empirical relation between the monthly chill accumulation calculated as hourly and daily chill units for the "Utah" and the "Latin" accumulated between 1 December -31 March, because this period includes the dormancy period and the date of occurrence of two main phases of the phenological development of cherry and peach: "swelling of the buds" "flowering" for the period 2000-.2015. expressed in a number of days.

In the present study, two of the already developed chilling models "Lantin model", based on an exponential "cold action" (Lantin 1973;1977) and "Utah" (Richardson et. al, 1974; Anderson et al,1986) were tested with our monthly and hourly data.

Utah Model

The Utah model bases on the quantification of Chilling Units (CU) and establishes different ranges of temperatures with a different contributions to dormancy completion. A chilling unit corresponds to one hour under temperatures between 2.5-9°C, a range that is considered the most effective temperatures on dormancy completion. Other ranges of temperatures are considered to have half (1,5-2,4 °C and 9,2-12,4°C), null (<1,4 °C and 12,5-15,9°C) or negative (>16 °C) contribution to dormancy. Calculation of chill units from hourly temperature data applying the Utah model was shown in (Tab.1) The annual amounts are accumulated for the period December - March, in the winter preceding the fruiting, because this period includes the dormancy period.

Table 1. Calculation of chill units from hourly temperature data applying the 'Utah' model (Richardson et al., 1974)

Temperature (ºC)	Chill units (CU)
< 1,4	0
1,5 - 2,4	0,5
2,5 - 9,1	1
9.2 - 12.4	0,5
12.5 - 15.9	0
16 - 18	0,5
> 18	-1

Lantin Model

An alternative chilling model was proposed by Lantin (1973; 1977), based on an exponential "cold action" function (Bidabe, 1967), and summed over the period of time:

Af = daily chill units accumulated (subsequently referred to as 'Lantin' units), tm, tM = minimum, maximum daily temperatures (°C), Q10 = temperature coefficient (expressed as the ratio of the effect at temperature T°C to the effect at - 10°C). The model works with daily temperature values.

$$Af = Q10^{-tm/10} + Q10^{-tM/10}, \text{ where:}$$

$Q_{10}=R_2/ R_1^{10ºC/(T_2-T_1)}$, where Q_{10} is temperature coefficient, R_1-day of temperature transition across 5ºC, R_2- day of temperature transition across 10ºC, $T_1$is 5ºC, T_2 is 10ºC. In our investigation, the value of (*Af)* varies from 1,6 to 2,6 depending on the temperature conditions during the years.

3. RESULTS AND DISCUSSION

Data manipulation- estimation of chill hours

During the 2000-2015 years, the derived chill unit models were applied to the hourly daily temperature data, and based on the date of dormancy completion the number of accumulated chill units was calculated with Lantin and Utah models. There were close linear relationships between the accumulated monthly values of daily and hourly calculated chill for all three chill models that can use hourly data, although the numerical values differed for the two calculations. Sample data are shown in Figure 2-3. Similar results and slopes were obtained for the two tested, with linear regressions explaining between87,6% and 88,7% of the variation in all cases. This implies that daily chill models are likely to be as useful as hourly chill models, and also that, if necessary, hourly chill can be estimated adequately from daily temperature data, using relationships such as that defined in Figure 1-2

Relationship between chill models

At the beginning of our investigation for tested the applicability of the models for use in operative agrometeorological practice, we look for the relationship between the two models. Fig. 1 and Table 2 show the average values of agrometeorological parameters. The relatively high values of the correlation index, and namely it being more than 0,85 - 0,95 and the immaterial equation error in tables give as grounds to recommend that these models be used with our monthly and hourly data in agrometeorological practice.

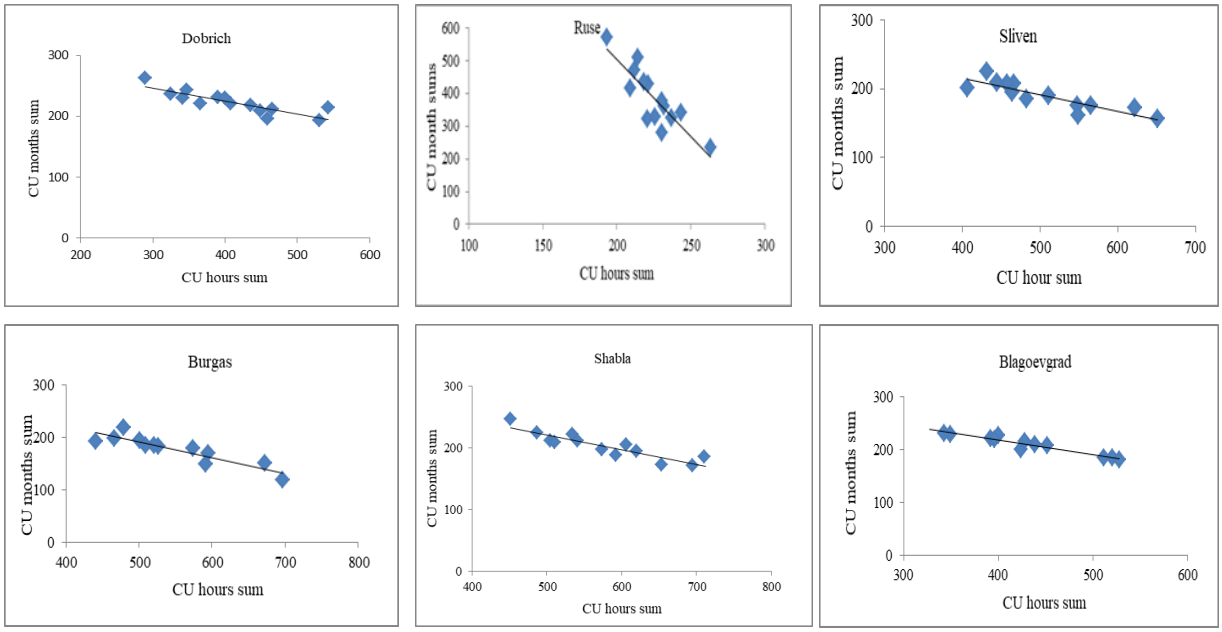


Fig. 1. Relationship between monthly and Horley chill accumulation calculated as hourly and daily chill units for the "Lantin" and "Utah" models for Peach trees (*Persica vulgaris* Mill.) and Cherry (*Prunus avium* L) in some representative stations in Bulgaria.

Table 2. Regression equations describe the dependence between monthly and Horley chill accumulation calculated as hourly and daily chill units for both models for Peach trees (*Persica vulgaris* Mill.) and Cherry (*Prunus avium* L). some representative stations in Bulgaria.

Stations	**Regression equations**	**R-Squared**	**r**
Dobrich	y= 0,211x+309,5	0,73	0,85
Ruse	y= 4,691x+144,1	0,73	0,85
Sliven	y= -0,2379x+310,3	0,76	0,87
Razgrad	y= -0,232x+314,2	0,83	0,91
Burgas	y= 0,299x+341,3	0,81	0,90
Shabla	y= -0,238x+340,5	0,80	0,90
Blagoevgrad	y= 0,277x+328,8	0,92	0,95
Lovech	y= -0,355x+358,3	0,81	0,90

The Utah model disregards sub-zero temperatures and probably relates more to the negative effect of higher temperatures. The highest monthly values (CU) for the Latin model are accumulated for Kneja-264,5 CU and Lovech - 235,5 CU, following by Dobrich - 234,5 and Razgrad - 226,2. The lowest values are accumulated in Burgas 162,1 and Chirpan 186,3. The highest hourly values CU for the Utah model are accumulated for Shabla-584,5 CU and Burgas 558,6 following by Sliven 505,4 and Blagoevgrad 448,5 The lowest values are accumulated in Kneja -334,4 and Lovech 373,4. With both Utah and Lantin models we provide comparable and precise results in the estimate of the chilling requirement of two cultivars in Bulgaria.

Relationship between chill models and "buds swelling"

The second point describes the relationship between monthly sums of chill units extracted for a range of "Lantin" model based on a calculation of accumulated chill and the number of days of "swelling of buds" for a Cherry (*Prunus avium* L). trees and a Peach tree (*Persica vulgaris* Mill) cultivars in Bulgaria. Fig. 2 and Table 3 show the relatively high values of the correlation index, and namely it being more than 0,80 - 0,88 and the immaterial equation error in tables 3 and 4.

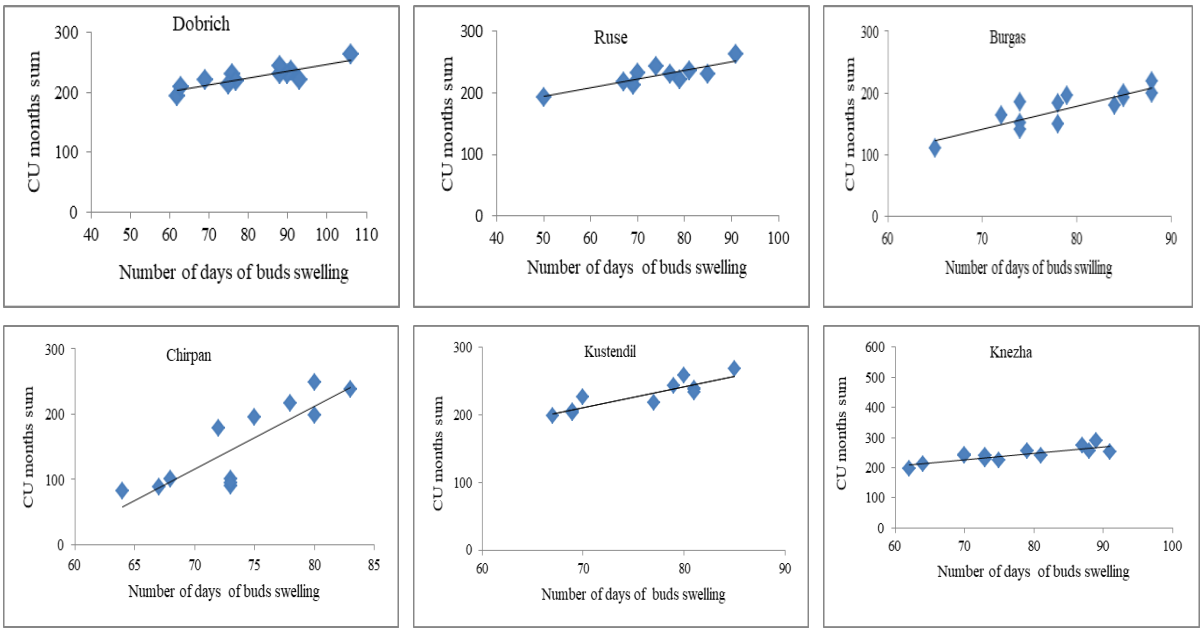


Fig. 2. Relationship between monthly sums of chill units extracted for a range of "Lantin" model based on a calculation of accumulated chill the number of days of "swelling of buds" for a Cherry trees (*Prunus avium* L.) in some representative stations in Bulgaria.

Table 3. Regression equations describe the dependence between monthly sums of chill units received with "Lantin" model accumulated chill from 1 December to 31 March and the number of days of swelling of buds for a Cherry (*Prunus avium* L.) for few representative stations in Bulgaria

Stations	**Regression equations**	**R-Squared**	**r**
Dobrich	y=1,148x+132,5	0,73	0,86
Ruse	y=1,414x+123,3	0,71	0,84
Silistra	y=1,729x+101,2	0,75	0,86
Burgas	y=3,706x+117,6	0,74	0,85
Chirpan	y=9,693x+562,7	0,72	0,84
Kustendil	y=3,146x-9,6	0,77	0,88
Blagoevgrad	y=6,528x-298,5	0,78	0,88
Knezha	y=2,147x+76,6	0,70	0,83
Lovech	y=3,151x-22,4	0,72	0,84

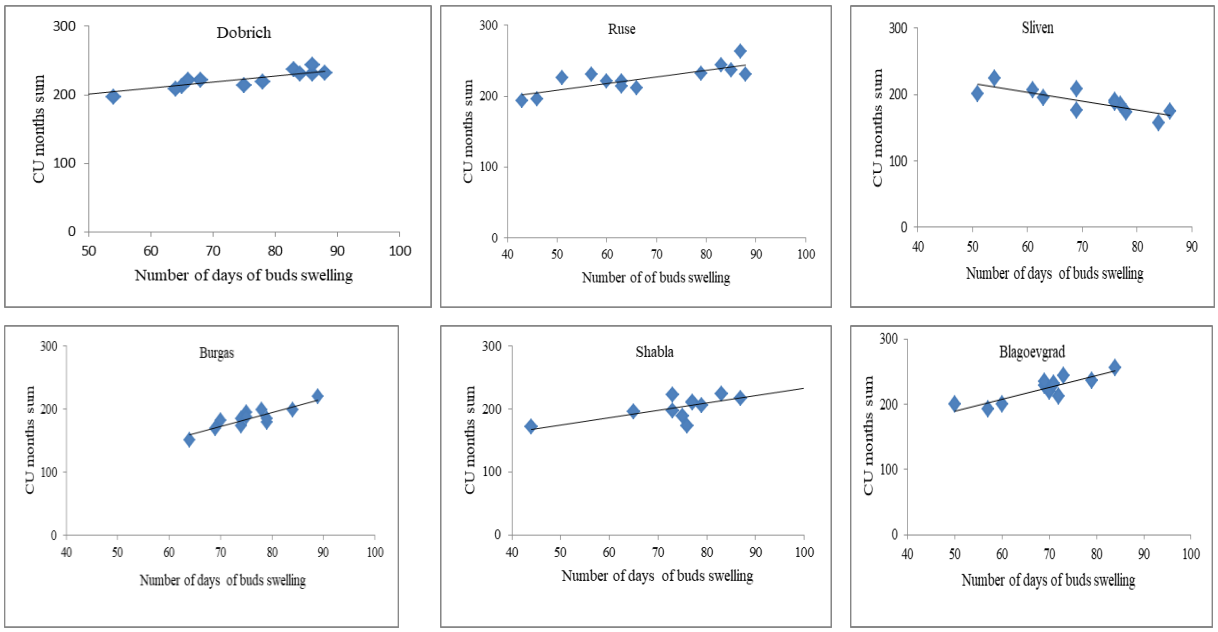


Fig. 3. Relationship between monthly sums of chill units extracted for a range of "Lantin" model based on a calculation of accumulated chill from 1 December to 31 March and the number of days of "swelling of buds" for a Peach tree (Persica vulgaris Mill.) in some representative stations in Bulgaria.

Table 4. Regression equations describe the dependence between monthly sums of chill units received with "Lantin" model based on a calculation of accumulated chill from 1 December to 31 March and the number of days of "swelling of buds" for a Peach trees (Persica vulgaris Mill.) in Bulgaria.

Stations	**Regression equations**	**R-Squared**	**r**
Dobrich	y= 0,862x+158,2	0,73	0,85
Ruse	y= 0, 949x+161,1	0,64	0,80
Sliven	y= -1,329x+283,5	0,64	0,80
Razgrad	y= 1,399x+127,9	0,73	0,85
Burgas	y= 2,241x+15,9	0,77	0,87
Shabla	y= 1,177x+115,4	0,63	0,79
Blagoevgrad	y= 1,805x+99,5	0,76	0,87
Lovech	y= 3,099x-19,7	0,79	0,88

Figures 4 and 5 and Tables 5 and 6 describes the relationship between monthly sums of chill units extracted for a range of "Lantin" model based on a calculation of accumulated chill and the number of days of "swelling of buds" for a Cherry (*Prunus avium* L). trees and a Peach trees (*Persica vulgaris* Mill) cultivars in Bulgaria. Show the relatively high values of the correlation index, and namely, it is more than 0,78 - 0,89.

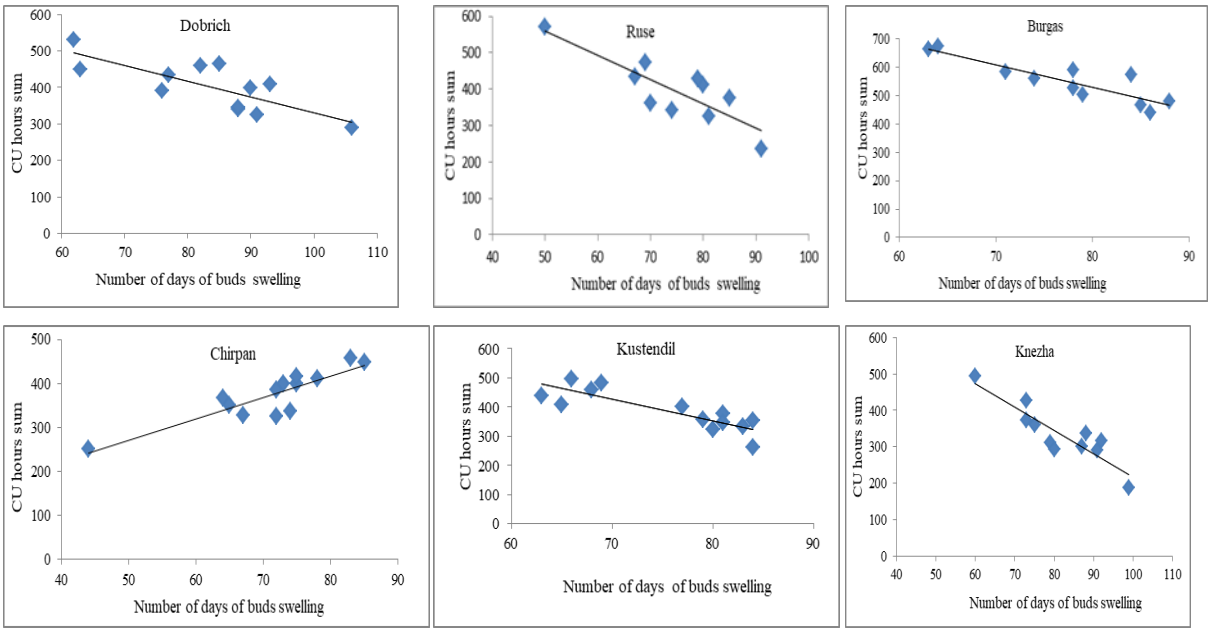


Fig. 4. Relationship between hour sums of chill units extracted for a range of "Utah" model based on a calculation of accumulated chill from 1 December to 31 March and the number of days of "swelling of buds" for a Cherry tree (*Prunus avium* L.) in some representative stations in Bulgaria

Table 5. Regression equations describe the dependence between hourly sums of chill units received with "Utah" model based on a calculation of accumulated chill from 1 December to 31 March and the number of days of "swelling of buds" for a Peach tree (Persica vulgaris Mill.) in Bulgaria

Stations	Regression equations	R-Squared	r
Dobrich	y=-4,335x+764,8	0,61	0,78
Ruse	y=-6,700x+895,1	0,71	0,84
Silistra	y=-6,550x+895,1	0,74	0,86
Burgas	y=-7,877x+1159,5	0,78	0,88
Chirpan	y=4,885x+26,2	0,77	0,88
Kustendil	y=-7,299x+937,8	0,71	0,84
Blagoevgrad	y=-0,232x+317,68	0,65	0,80
Knezha	y=-6,421x+858,8	0,80	0,89
Lovech	y=7,463x-193,7	0,74	0,86

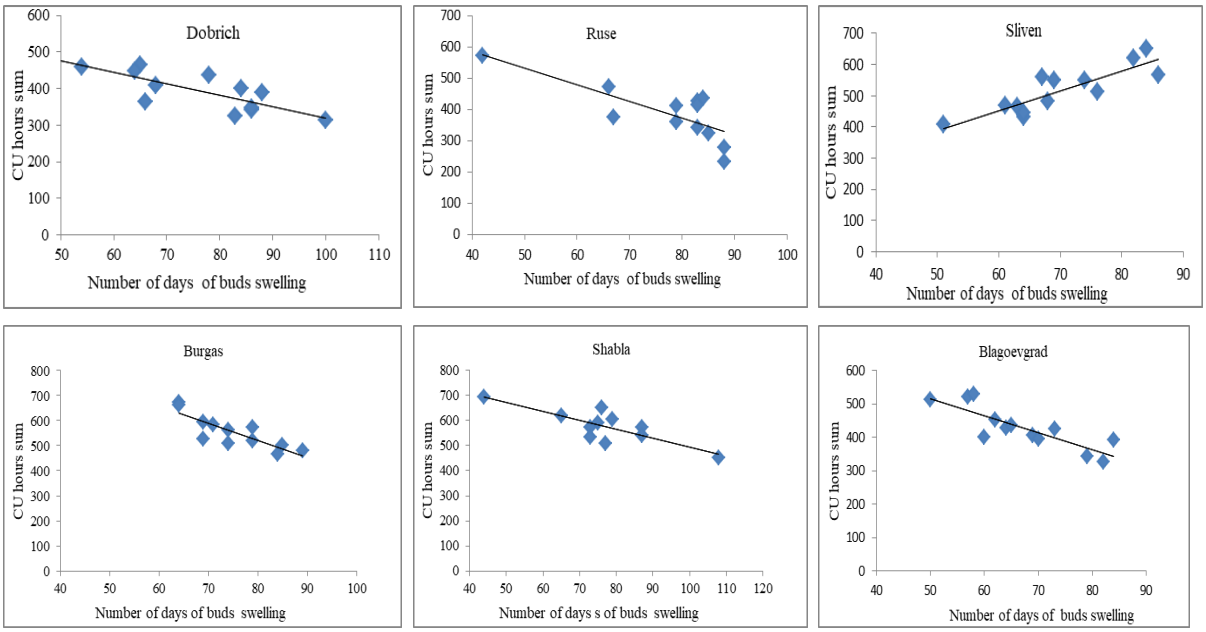


Fig. 5. Relationship between hour sums of chill units extracted for a range of "Utah" model based on a calculation of accumulated chill from 1 December to 31 March and the number of days of "swelling of buds" for a Peach tree (*Persica vulgaris* Mill.) in some representative stations in Bulgaria

Table 6. Regression equations describe the dependence between hour sums of chill units units received with "Utah" model based on a calculation of accumulated chill for a Peach trees (Persica vulgaris Mill.) in few representative stations in Bulgaria

Stations	**Regression equations**	**R-Squared**	**r**
Dobrich	y= -5,886x+799,7	0,71	0,86
Ruse	y= -5,293x+796,1	0,61	0,78
Sliven	y= 6,357x+71,345	0,74	0,86
Razgrad	y= -5,886x+799,7	0,78	0,88
Burgas	y= 6, 851x+107,7	0,72	0,85
Shabla	y= -3,517x+847,1	0,65	0,80
Blagoevgrad	y= -5,133x+772,4	0,71	0,84
Lovech	y= -0,165x+268,3	0,77	0,88

Relationship between chill models and "flowering"

The next point describes the relationship between monthly sums of chill units extracted for a range of "Lantin" model based on a calculation of accumulated chill and the number of days of "flowering" for a Cherry (*Prunus avium* L). trees and a Peach tree (*Persica vulgaris* Mill) cultivars in Bulgaria. Fig. 6 and Fig.7 and Table 7 and Table 8 show the relatively high values of the correlation index, and namely it being more than 0,78 - 0,95 and the immaterial equation error.

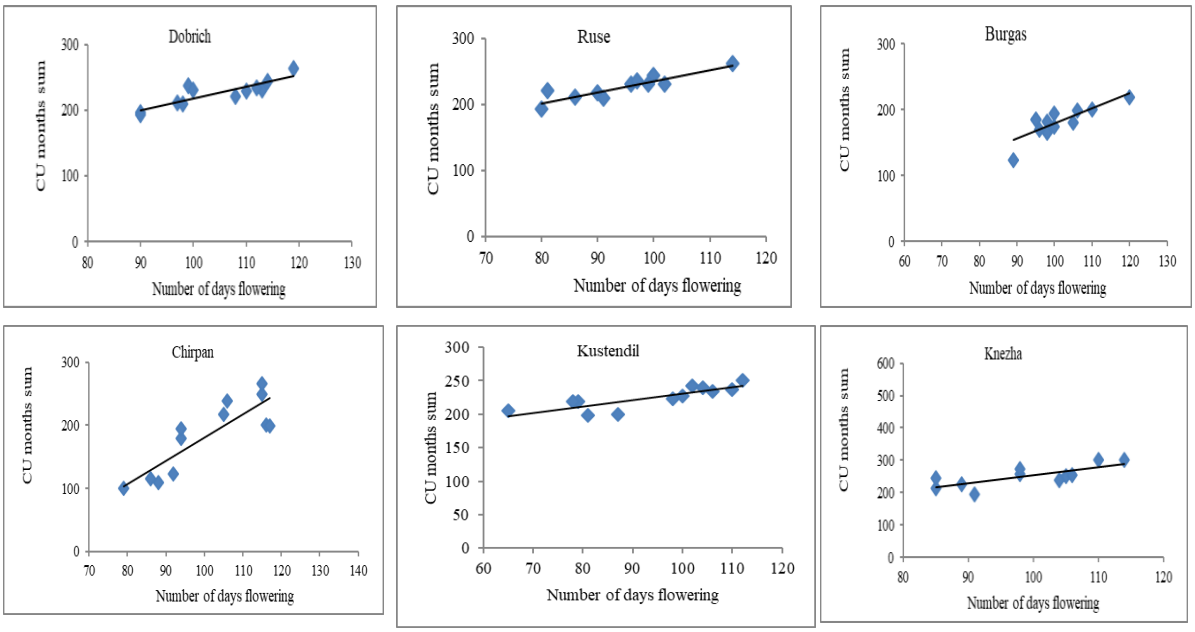


Fig. 6. Relationship between monthly sums of chill units extracted for a range of "Lantin" model based on a calculation of accumulated chill from 1 December to 31 March and the number of days of "flowering" for a Cherry tree (*Prunus avium* L.) in some representative stations in Bulgaria.

Table 7. Regression equations describe the dependence between monthly sums of chill units units received with "Lantin" model based on a calculation of accumulated chill from 1 December to 31 March and the number of days of "flowering" for a Cherry for few representative stations in Bulgaria

Stations	**Regression equations**	**R-Squared**	**r**
Dobrich	y=1,784x+39,3	0,75	0,86
Ruse	y=1,688x+67,3	0,79	0,89
Silistra	y=4,355-230,6	0,68	0,82
Burgas	y=2,318x-52,9	0,65	0,80
Chirpan	y=3,705-190,1	0,73	0,85
Kustendil	y=0,939x+136,6	0,68	0,82
Blagoevgrad	y=2,289x-0,6	0,71	0,84
Knezha	y=2,540x-0,3	0,61	0,77
Lovech	y=0,916x+154,6	0,62	0,78

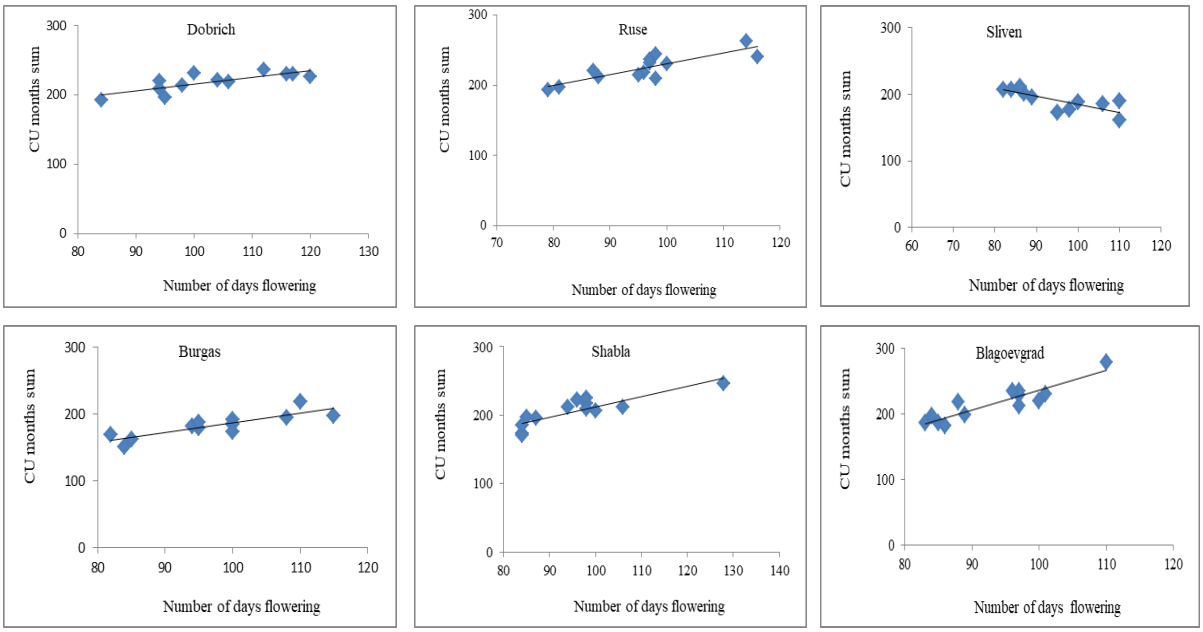


Fig. 7. Relationship between monthly sums of chill units extracted for a range of "Lantin" model based on a calculation of accumulated chill from 1 December to 31 March and the number of days of "flowering" for a Peach tree (*Persica vulgaris* Mill.) in some representative stations in Bulgaria

Table 8. Regression equations describe the dependence between monthly sums of chill units units received with "Lantin" model based on a calculation of accumulated chill from 1 December to 31 March and the number of days of "flowering" for a Peach trees (Persica vulgaris Mill.) for few representative stations in Bulgaria

Stations	**Regression equations**	**R-Squared**	**r**
Dobrich	y= 0,969x+118,8	0,61	0,78
Ruse	y= 1,529x+77,3	0,71	0,84
Sliven	y= -1,2334x+308,7	0,61	0,78
Razgrad	y= 1, 887x+34,3	0,73	0,85
Burgas	y= 1,451x+41,8	0,72	0,85
Shabla	y= 1,482x+64,1	0,73	0,85
Blagoevgrad	y= 3,023x+65,62	0,82	0,91
Lovech	y= 1,429x+68,3	0,76	0,87

The last point describes the relationship between monthly sums of chill units extracted for a range of "Utah" model based on a calculation of accumulated chill and the number of days of "flowering" for a Cherry (Prunus avium L). trees and a Peach tree (Persica vulgaris Mill) cultivars in Bulgaria. Fig. 8 and Fig.7 and Table 7 and Table 8 show the relatively high values of the correlation index, and namely it being more than 0,78 - 0,95 and the immaterial equation error.

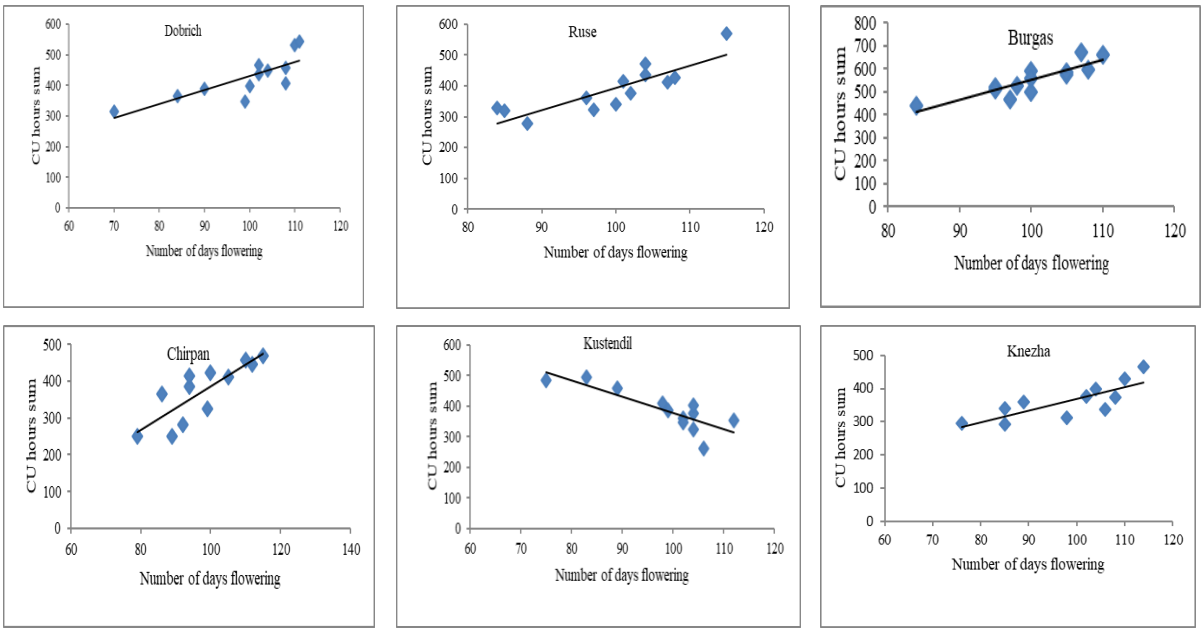


Fig. 8. Relationship between hourly sums of chill units extracted for a range of "Lantin" model based on a calculation of accumulated chill from 1 December to 31 March and the number of days of "flowering" for a Cherry tree (*Prunus avium* L.) in some representative stations in Bulgaria.

Table 9. Regression equations describe the dependence between hourly sums of chill units units received with "Latin" model based on a calculation of accumulated chill from 1 December to 31 March and the number of days of "flowering" for a Cherry tree (*Prunus avium* L.) for few representative stations in Bulgaria.

Stations	**Regression equations**	**R-Squared**	**r**
Dobrich	y= 0,211x+309,5	0,73	0,85
Ruse	y= 4,691x+144,1	0,73	0,85
Sliven	y= -0,2379x+310,3	0,76	0,87
Razgrad	y= -0,232x+314,2	0,83	0,91
Burgas	y= 0,299x+341,3	0,81	0,90
Shabla	y= -0,238x+340,5	0,80	0,90
Blagoevgrad	y= 0,277x+328,8	0,92	0,95
Lovech	y= -0,355x+358,3	0,81	0,90

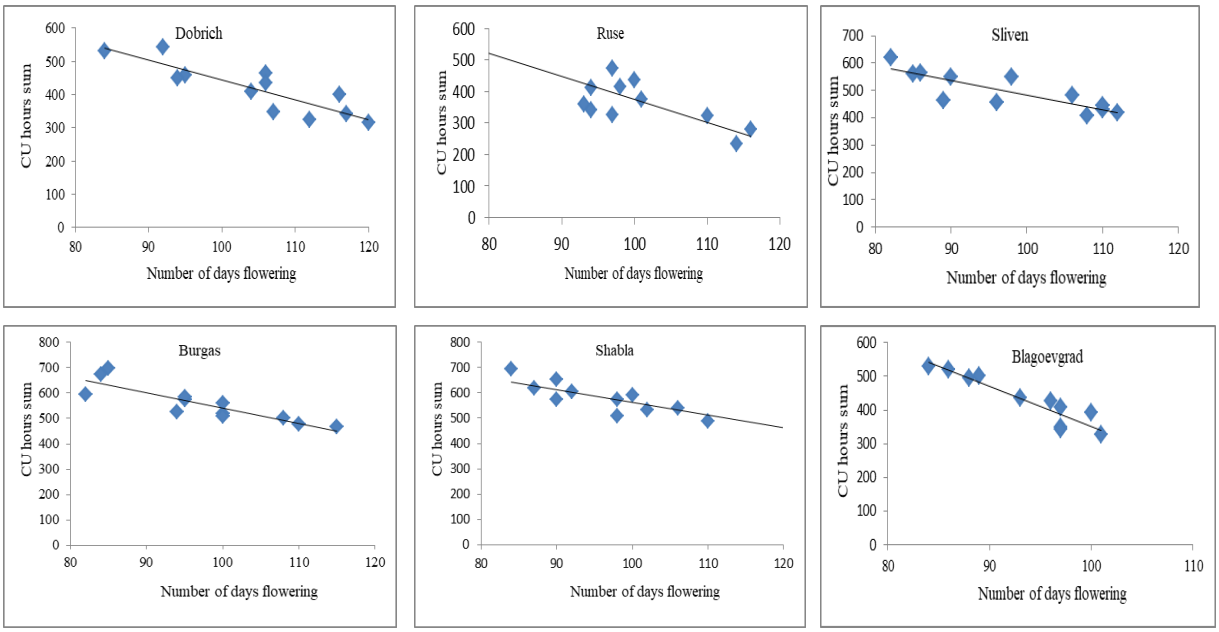


Fig. 9. Relationship between hourly sums of chill units received with "Lantin" model based on a calculation of accumulated chill from 1 December to 31 March and the number of days of "flowering" for a Peach trees (*Persica vulgaris* Mill) in some representative stations in Bulgaria.

4. CONCLUSIONS

To assess the conditions during the dormant period in fruit crops for the first time for Bulgaria were tested and calibrated the two considered models "Utah model" and "Lanthin model". A good correlation was found between the two models, which were tested for 11 agrometeorological stations for the period 2000-2015, grouped according to the similarity of the agrometeorological conditions, which allows their application in the conditions of Bulgaria. Good a relationship has been established between the two tested models and the dates of occurrence of the two main phases of the development of fruit trees: "swelling of the buds" and "flowering". This allows the models to be developed and tested in Bulgaria.

With both Utah and Lantin models we provide comparable and precise results in the estimate of chilling requirement a Peach tree (*Persica vulgaris* Mill) and a cherry(*Prunus avium* L). trees cultivars in Bulgaria.

ACKNOWLEDGMENTS

This work was supported by the Bulgarian Ministry of Education and Science under the National Research Programme "Healthy Foods for a Strong Bio-Economy and Quality of Life" approved by DCM # 577 /17.08.2018.

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