

# Chilling Unit Zonning for the Development of Temperament Fruit Trees in Highland Communities, Thai Nguyen, Vietnam

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**Abstract:** Thai Nguyen is located in the subtropical region, some regions are strongly influenced by the northeast monsoon, so the chilling unit is higher than some other regions. Temperate fruit trees (pears, persimmons, plums), annual trees that need a certain degree of chilling unit in the winter to differentiate flower buds, this requirement makes the above fruit tree species only suitable for growing in cold climates. high mountain areas in Vietnam. Zoning the accumulated chilling unit is a decisive step in determining areas to develop temperate fruit trees in highland communes, Thai Nguyen, Vietnam. Total area with chilling unit > 150 cu where temperate fruit tree varieties can be grown in highland communes: 75,312.37 hectares (accounting for 46.53% of total natural area): Very little cold region: 44,710, 7 hectares (accounting for 59.3%), it is recommended to test pear, persimmon, and plum; Less cold region: 20,687.83 hectares (accounting for 27.47%), it is recommended to grow pears, persimmons, and plums; Medium cold region: 6,315.64 hectares (accounting for 8.39%), recommended planting pears, persimmons, plums; Cold region: 3,598.2 hectares (accounting for 4.78%), recommended planting pears, persimmons, and plums. The focus region for developing fruit trees in terms of Chilling unit is Vo Nhai district, Dong Hy district, Phu Luong district.

**Key words:** temperate fruit trees, highland communes, Thai Nguyen, Vietnam, the chilling unit

## 1. Introduction

### 1.1 The Need for Research

Thai Nguyen is located in the subtropical region, some areas are strongly influenced by the northeast monsoon so the chilling unit is higher such as the northern districts of Vo Nhai, Dong Hy and Phu Luong.

Temperate fruit trees (pears, persimmons, plums), annual trees that need a certain degree of chilling unit in the winter to differentiate flower buds, this requirement makes the above fruit tree species only suitable for growing in cold climates. high mountain regions in Vietnam. This is a great advantage in cold high mountains even in hot tropical regions.

To produce temperate specialty fruit trees, we must properly evaluate the chilling unit resources of

highland communes, and on that basis, arrange suitable varieties for each specific region, to be able to exploit the advantages of natural conditions, especially in importing new varieties, avoiding losses when importing unsuitable varieties, not chilling unit enough, with little or no flowering and fruiting, or no harvest.

Thai Nguyen province has a low chilling unit, so the area of temperate fruit trees in the province is insignificant, production is fragmented and small, and in particular, there are no typical subtropical or temperate fruit trees with high demand. Low chilling unit requirement < 300 CU. Meanwhile, in the province's territory, there are many places with typical subtropical climate conditions such as highland communes in Vo Nhai, Dinh Hoa, Phu Luong, Dong Hy districts that are currently planting production forests and growing row crops. year, or low efficiency slash-and-burn farming. Among these, it is possible to shift to growing temperate fruit trees.

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Partition of accumulated chilling unit is the decisive step in determining regions to develop temperate fruit trees in Thai Nguyen province, Vietnam.

### 1.2 Objective

- Altitude zoning of highland communes, Thai Nguyen, Vietnam.
- Zoning of accumulated chilling unit in highland communes, Thai Nguyen, Vietnam;
- Select temperate fruit tree varieties suitable for the cold conditions of Thai Nguyen, Vietnam.

### 1.3 Subject and Scope of Research

- Research object: Temperate fruit tree varieties: Pear varieties: BV1, Tai Nung 2, DV1; Persimmon varieties: MC1 (Fuju) and Jiro persimmon originate from Japan; Plum varieties: Propic Beauty; Chilling unit in highland communes, Thai Nguyen, Vietnam
- Scope of research: Highland communes of Thai Nguyen province, Vietnam, concentrated in 6 districts including: Vo Nhai, Dai Tu, Phu Luong, Dinh Hoa, Dong Hy and Pho Yen.

## 2. Research Methods

### 2.1 DEM Method: For Building Elevation Zoning Maps<sup>1</sup>

#### 2.1.1 What is DEM?

A digital elevation model (DEM) is a numerical representation of the continuous change of elevation in uniform space.

DEM is stored differently depending on whether the data type is Raster or Vector.

#### 2.1.2 Method to Create DEM

DEM can be represented by:

Raster — a grid of squares

In the Raster DEM model (GRID) it looks like a matrix of squares and divided into rows and columns.

Each cell contains the height value of the cell's center point.

#### 2.1.3 DEM Construction Method

Build DEM from contour lines:

This is the standard method for building DEMs in a GIS environment. For an area where some terrain information is available, constructing a DEM from contour lines must go through the following steps:

Step 1: Digitize the contour lines, which can be done in one of the following two ways:

Automatically digitize scanned images (scanning): convert information from photos or maps into raster print files. For good results, contour maps should not include other information. The map is then converted to vector format using specialized software, but each contour line must be manually assigned a code. If the source image is not clear, this method is more labor-intensive than digitizing.

Manual digitization: Using a digitizer to digitize contour lines is still considered the standard method for building a DEM. Each contour line is individually digitized and assigned a code representing the corresponding elevation.

Step 2: Rasterize contour lines: performed by rasterizing functions of specialized software. The important issue here is choosing the size of the pixels through which the contour lines pass, which are automatically assigned a value equal to the height of the contour line itself.

Step 3: Interpolate rasterized contour lines: From the rasterized contour lines, you can interpolate to other contour lines, so each pixel in the map will receive the value for the center point of the pixels.

Step 4: Build the TIN model, usually done with Voronoi diagrams.

This method serves to build elevation zoning maps of highland communes, Thai Nguyen with elevation  $\leq 200$  m;  $> 200-350$  m;  $> 350-500$  m;  $> 500-600$  m;  $> 600$  m.

### 2.2 Prochill Method for Determining Chilling Unit (CU)

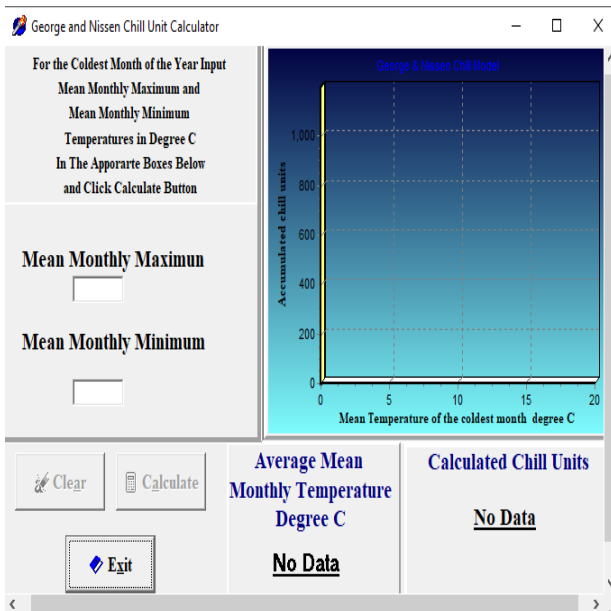
#### 2.2.1 Prochill Software

<sup>1</sup> Available online at: <https://vi.wikipedia.org>.

This method was developed by authors Alan George and Bob Nissen (1998) [1] of Maroochy Subtropical Fruit Research Center, Queensland.

Prochill is a method that is considered to have many advantages, suitable for assessing the coldness of localities to develop temperate fruit trees with low chill requirements (Low chill) in the world.

Prochill software interface:



Explain:

**Mean Monthly Maximum**

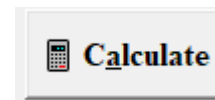
Mean Monthly Maximum: Average highest temperature per day of the coldest month of the year (Sum of highest temperature of all days in the coldest month/30 days).

**Mean Monthly Minimum**

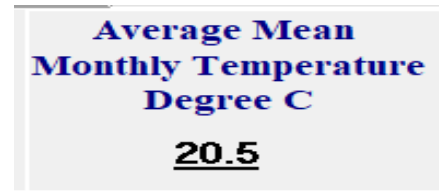
Mean Monthly Minimum: Average lowest daily temperature of the coldest month of the year (Sum of lowest temperature of all days of the month/30 days).



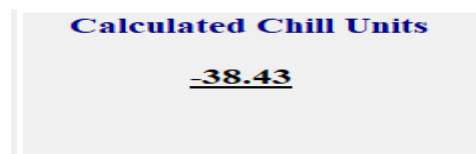
Clear: Delete data/re-enter.



Calculate: Calculate (average coldness and temperature).



Average Mean Monthly Temperature Degree: Average maximum and minimum temperature of the coldest month.



Calculate Chill Units: Coldness (CU).



Exit: Exit Prochill software

## 2.2.2 Use the Formula to Calculate Chilling Unit

Built by authors Alan George and Bob Nissen (1998)

[1].

$$Y = a + b / \sqrt{x}$$

Y = Refrigeration Unit (CU)

$$a = -1425.5$$

$$b = 6280.2$$

x = Average maximum and minimum temperature of the coldest month ((Mean Monthly Maximum + Mean Monthly Minimum)/2)

## 2.3 Other Methods

Build maps using Microstation and ArcView software; ArGIS; Map digitization method with the help of the geographic information system (GIS) and Mapinfo software is used to digitize and save map information layers and thematic maps to the computer.

such as altitude zoning map, cumulative chilling unit (CU) zoning map.

### **3. Research Results**

#### *3.1 Altitude Zoning of Highland Communes, Thai Nguyen, Vietnam*

Total natural area of highland communes: 161,851.27 hectares, concentrated mainly in Vo Nhai district: 82,786.37 hectares; Dong Hy district: 26,959.96 hectares; Dinh Hoa district: 21,518.32 hectares; Phu Luong district: 13,950.27 hectares; Dai Tu district: 13,370.74 hectares; Pho Yen City: 3,265.63 hectares

##### **3.1.1 The Regions Has an Altitude of > 600 Meters**

Area with altitude > 600 meters: Total area of 3,598.2 hectares, of which concentrated in Vo Nhai district: 2,811.48 hectares (Nghinh Tuong commune: 1,317.3 hectares; Than Sa commune: 554.5 hectares; Sang Moc commune: 369.03 ha; Phu Thuong commune: 206.72 ha; Thuong Nung commune: 182.62 ha; Vu Chan commune: 175.48 ha...); Dai Tu district: 553.39 hectares (Cat Xe commune: 269.07 hectares; Yen Lang commune: 193.37 hectares; Minh Tien commune: 90.96 hectares); Dinh Hoa district: 161.32 hectares (Linh Thong commune: 127.46 hectares...); Dong Hy district: 72.01 hectares (Van Lang commune: 68.02 hectares...).

##### **3.1.2 The Regions Has an Altitude of > 500-600 Meters**

Area with altitude from > 500-600 meters: Total area: 6,315.64 hectares, of which concentrated mainly in Vo Nhai district: 4,894.42 hectares (Than Sa commune: 1,573.97 hectares; Thuong Nung commune: 810.99 hectares; Nghinh Tuong commune: 694.83 hectares; Vu Chan commune: 580.87 hectares; Sang Moc commune: 546.44 hectares; Phu Thuong commune: 443.32 hectares; Dinh Hoa district: 537.67 hectares (Linh Thong commune: 294.69 hectares; Bao Linh commune: 98.86 hectares; Lam Vi commune: 78.49 hectares...); Dong Hy district: 481.33 hectares (Van Lang commune: 387.56 ha; Tan Long commune:

92.08 hectares...); Dai Tu district: 380.62 hectares (Yen Lang commune: 169.89 hectares; Minh Tien commune: 163.55 hectares...)...

##### **3.1.3 The Regions Has an Altitude of > 350-500 Meters**

Area with altitude from > 350-500 meters: Total area: 20,687.83 hectares, of which concentrated mainly in Vo Nhai district: 15,064.45 hectares (Than sa commune: 3,129.37 hectares; Sang Moc commune: 1,970.13 hectares; Nghinh Tuong commune: 1,960.9 hectares; Vu Chan commune: 1,725.38 hectares; Thuong Nung commune: 916.16 hectares; Lau Thuong: 555.43 hectares; Dan Tien commune: 247.09 hectares; Trang Xa commune: 240.21 hectares; Binh Long commune: 192.34 hectares; La Hien commune: 191.32 hectares); Dinh Hoa district: 2,231.68 hectares (Linh Thong commune: 542.76 hectares; Quy Ky commune: 519.86 hectares; Bao Linh commune: 508.25 hectares; Lam Vy commune: 359.23 hectares; Tan Thinh commune: 301.58 hectares); Dong Hy district: 2,220.83 hectares (Van Lang commune: 1,317.07 hectares; Tan Long commune: 645.1 hectares; Cay Thi commune: 192.36 hectares; Hop Tien commune: 63.11 hectares...); Dai Tu district: 774.98 hectares (Yen Lang commune: 312.13 hectares; Minh Tien commune: 270.16 hectares; Cat Ne commune: 142.96 hectares...); Phu Luong district: 342.31 hectares (Yen Ninh commune: 270.69 hectares...); Pho Yen City: 53.57 hectares (Thanh Cong Commune: 53.57 hectares).

##### **3.1.3 The Regions Has an Altitude of > 200-350 Meters**

Area with altitude from > 200-350 meters: Total area: 44,710.7 hectares, of which concentrated in Vo Nhai district: 27,048.17 hectares (quite large scale in most communes in the district: Sang Moc commune: 3,730.22 hectares; Than Sa commune: 3,337.94 hectares; Nghinh Tuong commune: 3,043.56 hectares; Lien Minh commune: 1,793.35 hectares; Phu Thuong commune: 1,747.34 hectares; Trang Xa commune: 1,608.82 hectares; Dan Tien commune: 1,180.16

hectares; La Hien commune: 880.45 hectares; Cuc Duong commune: 843.04 hectares; Binh Long commune: 696.62 hectares); Dinh Hoa district: 8,751.68 hectares (Quy Ky commune: 3,173.01 hectares; Tan Thinh commune: 2,217.89 hectares; Bao Linh commune: 1,427.94 hectares; Lam Vy commune: 1,143.35 hectares; Linh Thong commune: 789.48 hectares); Dong Hy district: 4,649.76 hectares (Van Lang commune: 1,381.1 hectares; Tan Long commune: 1,332.36 hectares; Cay Thi commune: 835.54 hectares; Hop Tien commune: 771.18 hectares; Van Hoa commune: 329.59 hectares); Phu Luong district: 2,067.38 hectares (Yen Ninh commune: 1,137.5 hectares; Dong Dat commune: 402.72 hectares; Yen Do commune: 356.32 hectares; Phan Me commune: 170.83 hectares); Dai Tu district: 2,012.09 hectares (Yen Lang commune: 785.5 hectares; Cat Ne commune: 408.95 hectares; Minh Tien commune: 359.84 hectares; Phu Lac commune: 180.09 hectares; Tien Hoi commune: 164.01 hectares; Duc Luong commune: 113.7 hectares); Pho Yen City: 181.62 hectares (Thanh Cong Commune: 181.62 hectares).

3.1.4 The Regions Has an Altitude of  $\leq 200$  meters

Area with altitude  $\leq 200$  meters: Total area: 86,538.9 hectares. This is a low area distributed mostly in districts and cities. Concentrated heavily in Vo Nhai district: 32,967.83 hectares (Dan Tien commune: 3,747.83 hectares; Yen Ninh commune: 5,311.19 hectares; Sang Moc commune: 3,062.97 hectares...); Dong Hy district: 19,536.04 hectares (Van Han commune: 6,276.63 hectares; Hop Tien commune: 4,747.5 hectares; Van Lang commune: 3,129.53; Cay Thi commune: 3,024.69 hectares...); Phu Luong district: 11,524.89 hectares (Yen Ninh commune: 3,282.29 hectares; Yen Do commune: 3,196.46 hectares; Dong Dat commune: 3,112.8 hectares...); Dinh Hoa district: 9,835.96 hectares (Tan Thinh Commune: 3,454.26 hectares...); Dai Tu district: 9,649.65 hectares (scattered distribution in communes with each commune size  $< 3,000$  hectares); Pho Yen City: 3,024.52 hectares (Thanh Cong Commune: 3,024.52 hectares).

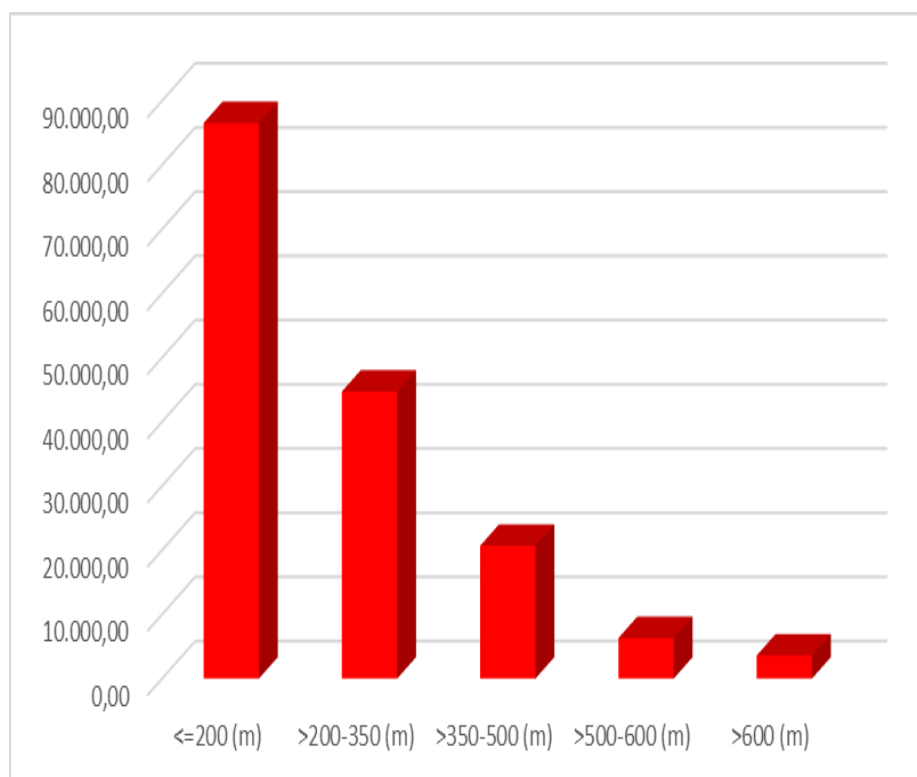


Fig. 1 Altitude zoning area of highland communes, Thai Nguyen (ha).

### *3.2 Chilling Unit Zoning of Highland Communes, Thai Nguyen, Vietnam*

#### **3.2.1 Some Research Results on Chilling Unit Zoning for Fruit Trees in Vietnam**

According to A. P. George, R. J. Nissen (1998) [1], have researched and recommended plum varieties, suitable for use in subtropical climates, requiring low cold temperatures in Australia, Thailand, Laos and Vietnam. These varieties are divided into 4 levels in terms of cooling unit requirements:

Group 1: Areas with chilling unit from 50 to 150 CU;

Group 2: Areas with chilling unit from 150 to 300 CU;

Group 3: Areas with chilling unit from 300 to 450 CU;

Group 4: Areas with chilling unit from 450 to 600 CU.

In areas with chilling unit from 50 to 150 CU, plum varieties require very few chilling unit. In areas with chilling unit from 150 to 300 CU, plum varieties require fewer cooling units. Areas with chilling unit from 300 to 450 CU for plum varieties that require just about refrigeration units. In areas with chilling unit from 450 to 600 CU, plum varieties have high requirements for chilling unit

According to Vu Manh Hai and CS (2021), when studying the evolution of chilling unit (cu) in relation to the development of temperate fruit trees in some Northern Mountainous provinces of Vietnam (Journal of Science and Technology Vietnam Agriculture, No. 05(126)/2021) has classified temperate fruit trees:

Group 1: Areas with chilling unit < 100 CU

Group 2: Areas with chilling unit from > 200- <400 CU (concentrated 200-300 cu)

Group 3: Areas with chilling unit from 450- < 650 CU

Areas with chilling unit < 100 CU are not recommended for growing temperate fruit trees

(except for special cases with chilling unit of approximately 100 cu such as Son Dong and Tien Yen. Areas with chilling unit > 200- < 400 CU (concentrated at 200 CU). -300 cu) for temperate fruit trees with medium chill cultivars). Areas with altitudes > 1600 meters are not recommended for growing temperate fruit trees

According to Le Duc Khanh and colleagues (2007) [2] on the topic “Research on integrated technical measures to develop high-quality temperate fruit trees (plums, persimmons, peaches) in the Northern mountainous provinces”, the topic “an independent state-level financial institution” was given a computer software program — Prochill by author Bob. Nissen of the Maroochy Subtropical Fruit Research Center, Queensland to calculate CU refrigeration units very conveniently, according to which the research team Research has applied calculations and divided the chilling unit of the Northern Midlands and Mountains region of Vietnam into cold regions as follows:

Group 1: Areas with chilling unit from 100-250 cu.

Group 2: Areas with chilling unit from 250-400 cu.

Group 3: Areas with chilling unit over 400 cu.

Regions with chilling unit from 100-250 cu can only grow groups with very little chilling unit requirements (including Fuyu persimmons), fresh fruit products in these regions have been on the market very early. Areas with 250-400 cu can grow groups with chilling unit very little, little and medium requirements for chilling unit (including Fuyu persimmons), harvest time from late March to June; Fuyu crispy persimmons are harvested at the end of August. Regions with chilling unit above 400 cu can grow varieties with low, medium and medium high chilling unit requirements (including Fuyu persimmons), but seasonal Harvest will be later than in the above regions.

According to “Chilling unit”<sup>2</sup>, Australia is divided into chilling unit to grow typical temperate fruit trees:

<sup>2</sup> Available online at: <https://www.heritagefruittrees.com.au/>.

Group 1: Areas with low chilling unit < 450 cu

Group 2: Areas with average chilling unit from 450 to 650 cu

Group 3: Areas with high chilling unit > 650 cu

Areas with low chilling unit < 450 cu varieties with low chilling unit in areas with low chilling unit.

Medium-hardiness zones between 450 and 650 cu can grow all low and medium-hardiness fruit varieties provided the low-hardiness trees are protected from late spring frosts. Chilling unit zones > 650 cu can grow all low, medium and high chilling unit fruit varieties provided that low and medium chilling unit plants are protected from late spring frosts.

**3.2.2 Some Temperate Fruit Tree Varieties Have Been Put into Experimental Research in Highland Communes, Thai Nguyen, Vietnam**

The need for chilling unit is a genetic characteristic of temperate fruit tree varieties, so when considering planting temperate fruit trees, it is necessary to calculate the chilling unit in the area expected to be planted as a necessary condition. The chilling unit depends mainly on the altitude and direction of the northeast monsoon. Varieties put into trial planting in Thai Nguyen: BV1, DV1, Tai Nung 2, Fuji (MC1), Jiro and Propic Beauty.

BV1 pear variety: An imported variety from Taiwan, the fruit skin is dark brown, when ripe, the skin turns yellow brown, with few spots, the fruit flesh is ivory white, does not darken when stored for a long time, the fruit is spherical, the fruit is large. Brix level 11.3%, not much grit, soft flesh, no astringent taste, characteristic aroma, good preservation ability. The variety requires a northeast monsoon chilling unit of 200-300 CU, harvest time is from mid-July to early August. The BV1 variety has been imported and tested by the Sa Pa Temperate Plant Research and Development Center and has been commercialized. Varieties to grow in many places

DV1 pear variety. Temperate fruit trees that require low chilling unit below 200 CU include the DV1 pear variety originating from Taiwan, now renamed Dong

Van 1, which appears to be very suitable for local climatic conditions and has many varieties. The most outstanding advantages include: flowering later but ripening before local pear varieties, so the fruit can be sold early to the market. This pear variety has been grown in many places and has been commercialized as a variety from China. Pho Bang Agricultural and Livestock Research Center, Dong Van town, Ha Giang.

Tai Nung 2 pear variety also originates from Taiwan, but was tested by Taiwanese experts in Ba Vi and proved to be very suitable, then moved to Moc Chau 19/5 Agricultural Service Cooperative, Son La. Up to now, it can be said that Taiwanese pear is gradually asserting its superiority. It is hoped that it will become a strong tree to develop into a specialized commodity cultivation area and be widely recommended for production. Peeled skin does not darken, so it is very popular with people.

Fuyu persimmon variety and Jiro peach variety. The Fuyu persimmon variety is a popular variety grown in Japan and has been recognized by the Ministry of Agriculture and Rural Development of Vietnam as a temporary variety named MC1. Boonprakob (1998) recommends using peach cultivars for subtropical climates of Australia and northern Thailand including: Fuyu (late ripening), Ichikikei Jiro (main crop).

Propic Beauty plum variety: ACIAR project: "Development of temperate fruit trees with low need for chilling unit suitable for Australia, Thailand, Laos and Vietnam", code: CS1/2001/027 imported plum variety from Australia there is a request of 100-250 CU. The imported varieties tested in the Moc Chau - Son La, Bac Ha, Sa Pa - Lao Cai regions showed that the plants grew well and initially showed signs of adapting to the ecological conditions of the deployed areas. Among them, the Propic beauty plum variety is considered very suitable for areas with little cold conditions [3].

Each plant variety has a different chilling unit. Varieties put into experimental planting.

Thai Nguyen has a fairly wide spectrum of adaptation to cold. Compared to other highland provinces, the chilling unit of Thai Nguyen province is not high, however, due to the direct influence of the northeast monsoon and the influence of climate change: winters are getting colder and colder. direction is getting higher and higher

The total area of chilling unit areas that can grow the above varieties in highland communes: 75,312.37 hectares, of which mainly concentrated in Vo Nhai district: 49,818.53 hectares; Dinh Hoa district: 11,682.35 hectares; Dong Hy district: 7,423.93 hectares; Dai Tu district: 3,721.08 hectares; Phu Luong district: 2,425.37 hectares..., the center for developing fruit trees in terms of chilling unit in highland communes is Vo Nhai district.

### 3.2.3 Chilling Zoning for Fruit Tree Varieties Included in Experimental Research in Highland Communes, Thai Nguyen, Vietnam

#### a) Cold Regions (Chilling Unit >300 CU)

Cold regions are suitable for most temperate fruit tree varieties tested. Total area is 3,598.2 hectares, of which concentrated in Vo Nhai district: 2,811.48 hectares (Nghinh Tuong commune: 1,317.3 hectares; Than Sa commune: 554.5 hectares; Sang Moc commune: 369.03 h; Phu Thuong commune : 206.72 hectares; Thuong Nung commune: 182.62 hectares; Vu Chan commune: 175.48 hectares...); Dai Tu district: 553.39 hectares (Cat Xe commune: 269.07 hectares; Yen Lang commune: 193.37 hectares; Minh Tien commune: 90.96 hectares); Dinh Hoa district: 161.32 hectares (Linh Thong commune: 127.46 hectares...); Dong Hy district: 72.01 hectares (Van Lang commune: 68.02 hectares...).

#### b) Medium Cold Regions (Chilling Unit > 250-300 CU)

The medium cold regions has a total area of: 6,315.64 hectares, of which concentrated mainly in Vo Nhai district: 4,894.42 hectares (Than Sa commune: 1,573.97 hectares; Thuong Nung commune: 810.99 hectares; Nghinh commune: Tuong: 694.83 hectares;

Vu Chan commune: 580.87 hectares; Sang Moc commune: 546.44 hectares; Phu Thuong commune: 443.32 hectares; Dinh Hoa district: 537.67 hectares (Linh Thong commune: 294.69 hectares; Bao Linh commune: 98.86 hectares; Lam Vi commune: 78.49 hectares...); Dong Hy district: 481.33 hectares (Van Lang commune: 387.56; Tan Long commune: 92.08 hectares...); Dai Tu district: 380.62 hectares (Yen Lang commune: 169.89 hectares; Minh Tien commune: 163.55 hectares...)...

#### c) Less Cold Regions (Chilling Unit > 200-250 CU)

The less cold regions has a total area of: 20,687.83 hectares, of which concentrated mainly in Vo Nhai district: 15,064.45 hectares (Than sa commune: 3,129.37 hectares; Sang Moc commune: 1,970.13 hectares; Nghinh Tuong commune: 1,960.9 hectares; Vu Chan commune: 1,725.38 hectares; Thuong Nung commune: 1,607.36 hectares; Phuong Giao commune: 916.16 hectares; Dan Tien commune: 247.09 hectares; Trang Xa commune: 240.21 hectares; Lien Minh commune: 192.34 hectares; Dinh Hoa district: 2,231.68 hectares (Linh Thong commune: 542.76 hectares; Quy Ky commune: 519.86 hectares; Bao Linh commune: 508.25 hectares; Lam Vy commune: 359.23 hectares; Tan Thinh commune: 301.58 hectares); Dong Hy district: 2,220.83 hectares (Van Lang commune: 1,317.07 hectares; Tan Long commune: 645.1 hectares; Cay Thi commune: 192.36 hectares; Hop Tien commune: 63.11 hectares...); Dai Tu district: 774.98 hectares (Yen Lang commune: 312.13 hectares; Minh Tien commune: 270.16 hectares; Cat Ne commune: 142.96 hectares...); Phu Luong district: 342.31 hectares (Yen Ninh commune: 270.69 hectares...); Pho Yen City: 53.57 hectares (Thanh Cong Commune: 53.57 hectares)

#### d) Very Little Cold Regions (Chilling Unit > 150-200 CU)

The very little cold regions has a total area of 44,710.7 hectares, of which concentrated in Vo Nhai district: 27,048.17 hectares (quite large scale in most communes in the district: Sang Moc commune:



3,730.22 hectares; Than Sa commune: 3,337.94 hectares; Nghinh Tuong commune: 3,290.89 hectares; Phuong Giao commune: 3,043.56 hectares; Vu Chan commune: 2,438.82 hectares; Lien Minh commune: 1,793.35 hectares; Phu Thuong commune: 1,747.34 hectares; Trang Xa commune: 1,608.82 hectares; Dan Tien commune: 1,538.64 hectares; Lau Thuong commune: 1,180.16 hectares; Thuong Nung commune: 918.33 hectares; La Hien commune: 880.45 hectares; Cuc Duong commune: 843.04 hectares; Binh Long commune: 696.62 hectares; Dinh Hoa district: 8,751.68 hectares (Quy Ky commune: 3,173.01 hectares; Tan Thinh commune: 2,217.89 hectares; Bao Linh commune: 1,427.94 hectares; Lam Vy commune: 1,143.35 hectares; Linh Thong commune: 789.48 hectares); Dong Hy district: 4,649.76 hectares (Van Lang commune: 1,381.1 hectares; Tan Long commune: 1,332.36 hectares; Cay Thi commune: 835.54 hectares; Hop Tien commune: 771.18 hectares; Van Hoa commune: 329.59 hectares); Phu Luong district: 2,067.38 hectares (Yen Ninh commune: 1,137.5 hectares; Dong Dat commune: 402.72 hectares; Yen Do commune: 356.32 hectares; Phan Me commune: 170.83 hectares); Dai Tu district: 2,012.09 hectares (Yen Lang commune: 785.5 hectares; Cat Ne commune: 408.95 hectares; Minh Tien commune: 359.84 hectares; Phu Lac commune: 180.09 hectares; Tien Hoi commune: 164.01 hectares; Duc Luong commune: 113.7 hectares); Pho Yen City: 181.62 hectares (Thanh Cong Commune: 181.62 hectares).

Each variety of temperate fruit trees has a different chilling unit. The varieties put into trial planting in highland communes in Thai Nguyen have a fairly wide spectrum of adaptation to chilling unit. Compared to other highland provinces, the chilling unit of Thai Nguyen province is not high, however, due to the direct influence of the northeast monsoon and the influence of climate change: winters are getting colder and colder. direction is getting higher and higher.

The total area of chilling unit areas > 150 cu can grow temperate fruit tree varieties in highland communes: 75,312.37 hectares (accounting for 46.53% of the total natural area).

Sort by district:

Vo Nhai district: 49,818.53 hectares (accounting for 66.15%)

Dinh Hoa district: 11,682.35 hectares (accounting for 15.51%)

Dong Hy district: 7,423.93 hectares (accounting for 9.86%)

Dai Tu district: 3,721.08 hectares (accounting for 4.94%)

Phu Luong district: 2,425.37 hectares (accounting for 3.22%)

Sort by cold level:

Very little cold regions: 44,710.7 hectares (accounting for 59.3%), Recommended testing of pear, persimmon and plum.

Less cold regions: 20,687.83 hectares (accounting for 27.47%), it is recommended to grow pear, persimmon and plum.

Medium cold regions: 6,315.64 hectares (accounting for 8.39%), Recommended planting of pear, persimmon and plum.

Cold regions: 3,598.2 hectares (accounting for 4.78%), recommended planting pear, persimmon and plum.

So in terms of chilling unit, the focus region for developing temperate fruit trees in highland communes is Vo Nhai district (Than Sa, Nghinh Tuong, Sang Moc, Vu Chan, Phuong Giao, Phu Thuong, Thuong Nung communes); Dong Hy district (Van Lang commune); Phu Luong district (Yen Ninh commune).

### Chilling Unit Zonning for the Development of Temperament Fruit Trees in Highland Communities, Thai Nguyen, Vietnam

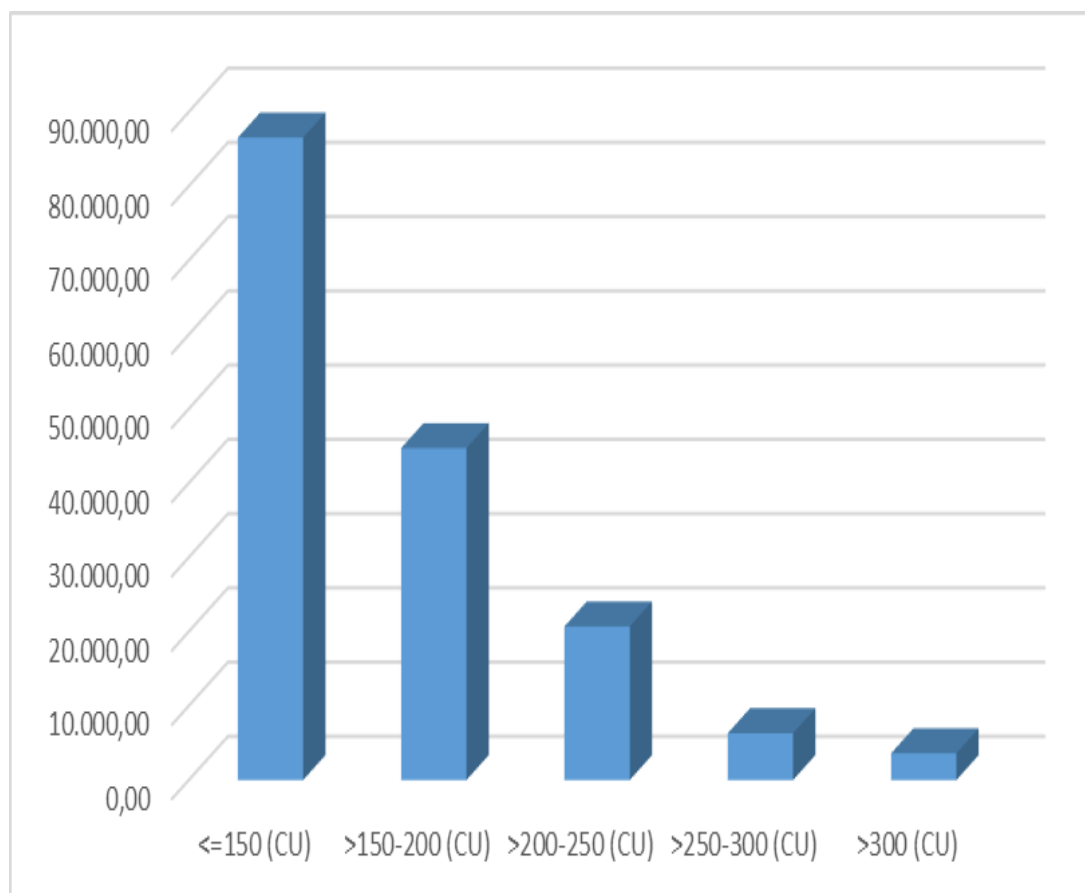


Fig. 2 Area of cumulative chilling unit in highland communes, Thai Nguyen (ha).

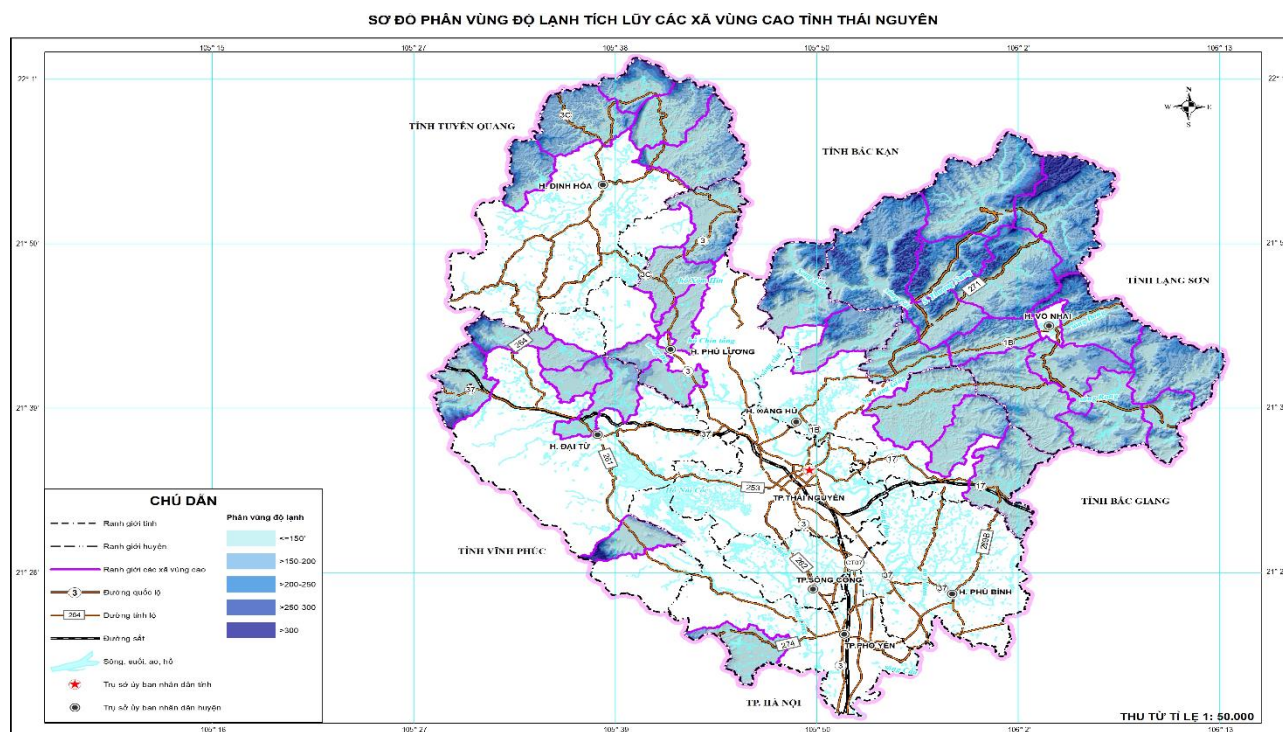
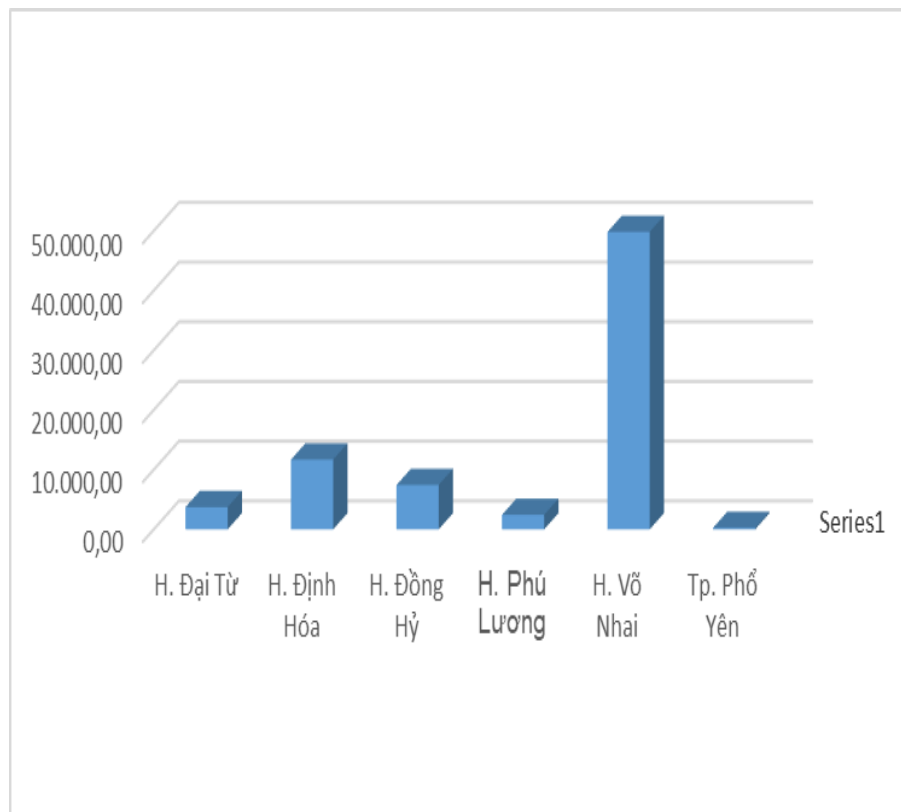
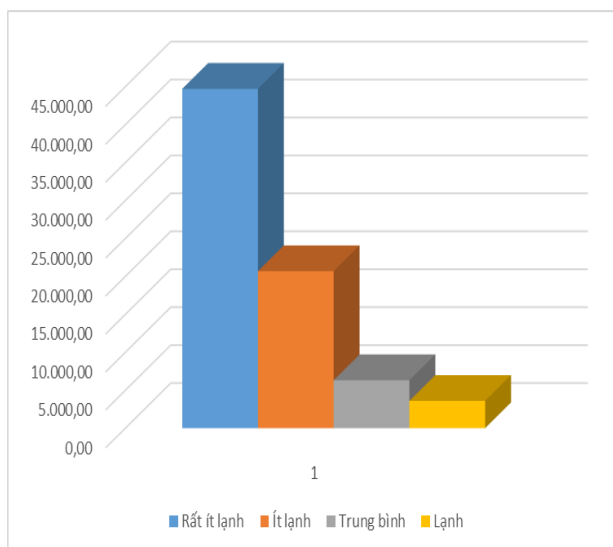


Fig. 3 Zoning diagram of accumulated chilling unit in highland communes, Thai Nguyen.



**Fig. 4** Potential chilling unit areas for developing temperate fruit trees in highland communes, Thai Nguyen, Vietnam.



**Fig. 5** Chilling unit zoning in highland communes, Thai Nguyen, Vietnam (ha).

#### 4. Conclusion

- 1) Total natural area of highland communes: 161,851.27 hectares. Area with altitude > 600 meters: 3,598.2 hectares; Area with altitude from > 500-600 meters: 6,315.64 hectares;

Area with altitude from > 350-500 meters: 20,687.83 hectares; Area with altitude from > 200-350 meters: 44,710.7 hectares; Area with altitude ≤ 200 meters: 86,538.9 hectares.

- 2) Total area of regions that can grow temperate fruit varieties in highland communes, Thai Nguyen, Vietnam: 75,312.37 hectares, divided by district: Vo Nhai District: 49,818.53 hectares (accounting for 66.15%); Dinh Hoa district: 11,682.35 hectares (accounting for 15.51%); Dong Hy district: 7,423.93 hectares (accounting for 9.86%); Dai Tu district: 3,721.08 hectares (accounting for 4.94%); Phu Luong district: 2,425.37 hectares (accounting for 3.22%)...
- 3) Chilling unit zoning of highland communes, Thai Nguyen, Vietnam for pear, persimmon and plum varieties with total area capable of developing temperate fruit trees: 75,312.37 hectares; Divided by regions: Very little cold

### Chilling Unit Zonning for the Development of Temperament Fruit Trees in Highland Communities, Thai Nguyen, Vietnam

area: 44,710.7 hectares (accounting for 59.3%), it is recommended to test pear, persimmon, and plum; Less cold areas: 20,687.83 hectares (accounting for 27.47%), it is recommended to grow pears, persimmons and plums; Medium cold regions: 6,315.64 hectares (accounting for 8.39%), recommended planting pears, persimmons, plums; Cold regions: 3,598.2 hectares (accounting for 4.78%), recommended planting pears, persimmons, and plums.

- 4) Regarding chilling unit, the central region for growing temperate fruit trees in highland communes and Thai Nguyen is Vo Nhai district (Than Sa, Nhenh Tuong, Sang Moc, Vu Chan, Phuong Giao, Phu Thuong, Thuong Nung communes); Dong Hy district (Van Lang

commune); Phu Luong district (Yen Ninh commune).

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