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Advantageous fruits in the North of Vietnam: Summarised issues on the study and production

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Abstract:

The Northern part of Vietnam has been considered as a big potential region in agriculture production generally and fruit development particularly. The diversified conditions in terms of land characterization and climatic meteorology especially light quality and temperature fluctuation between daytime and nighttime are regarded as decisive factors for the production of advantageous fruit crops. In the scope of the article, the main issues concerned with the study and production of some specified fruits in Northern provinces related to new policies and decisions issued and instructed by the Government and Ministry of Agriculture and Rural Development were accordingly summarised. It is obvious that fruit production in the North of Vietnam has had a lot of achievements in recent years and significantly contributed to the development of fruits in the whole country in which advantageous fruit crops played an important role which should be emphasized. What is more, the relationship among fruit growers represented by cooperatives, fruit processors represented by groups or companies and fruit consumers (businesses or supermarkets) was strongly formed and improved which made fruit conduction sustainably developed with time.

Keywords: **advantageous, fruit production chains, temperate fluctuation, temperate fruits.**

Classification number: **2.2**

1. Introduction

In recent years, the production of fruit crops in the whole country has developed remarkably as indicated by a rapidly continued increase in area under fruit cultivation, and productivity. This increase meets not only the domestic demand but also foreign export demands, resulting in a significant contribution to the growth of the Vietnamese agricultural sector and improving the living standard of Vietnamese farmers in various regions [1-3].

The specific ecological conditions in the Northern provinces of Vietnam characterized by the monsoon-affected tropical climate and variously changed topographies from location to location allow the development of different kinds of fruit crops including tropical fruits such as bananas, pineapple, mango… sub-tropical fruits such as oranges, pomelo, mandarin… and some temperate fruits, e.g. plum, peach, pear, persimmon, etc. [4].

As a matter of fact, some traditional locations of fruit production have been accordingly established and developed in the North of Vietnam, and fruit products of these regions were considered as locally specified ones that take an important role in the economic growth of the area. Pomelo in Hanoi ("Dien"

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cultivar particularly) and Hoa Binh, orange in Nghe An and Hoa Binh, king mandarin in Ha Giang and Tuyen Quang, bananas in Phu Tho and Hung Yen sugar apple in Lang Son and Quang Ninh, plum in Son La and Lao Cai, lychee in Bac Giang, etc. These fruits have all been traditionally cultivated on a large scale and attract consumers not only in Vietnam but also from abroad.

The total area under fruit cultivation in the North of Vietnam nowadays is estimated to be nearly 400,000 hectares, which accounts for approximately 40% in whole country. Provinces in the North Eastern zone is considered to have the biggest area (more than 150,000 hectares). There after ranks the second biggest one (the Mekong river delta), followed by the Red river delta zone with nearly 100,000 hectares and the North Western one (more than 70,000 hectares). The North of central cultivation zone ranks last in terms of area under fruit cultivation (about 69,000 hectares).

It is also mentioned that though fruit production in Northern provinces is hardly less developed compared to Mekong river delta production in terms of cultivating area and total production, some fruit crops are considered to be advantageous when grown in the North region because of specific conditions required by fruit varieties in which climate characteristics, atmosphere temperature, relative humidity and day-night temperature fluctuation are the key factors.

Some kinds of advantageous fruit crops available in the North of Vietnam which have been traditionally grown or effectively introduced from abroad should be included in this article in which some main issues related to the production and study are summarily focused.

2. Summarised issues concerned the study and production of advantageous fruit crops in the North in recent years

2.1. Lychee

Since lychee needs a sufficient quantity of low atmosphere temperature duration and relative humidity in winter for flower bud initiation (Table 1), the area under lychee cultivation in Vietnam is not as large as other fruit crops, mainly concentrated in the Northern provinces, especially in the Red river delta and North East region (account for more than 99% of litchi grown area and 15% fruit grown in the whole country) [4, 5].

Table 1. Relationship between lychee yield and some meteorological factors (calculated in 20 years for Phu Ho cultivar).

Items \ Months		XI	XII	I	II	III
Temp.	Impact Coefficient (B)	-121.7	-316.1	+258.1	-417.1	+19.9
	Correlative Coef. (rB)	-0.280	-0.822**	+0.149	-0.506	+0.215
Rainfall	Impact Coef. (C)	-71.5	-50.7	+77.8	+1.6	-1.1
	Correlative Coef. (rC)	-0.176	-0.661*	-0.462	+0.005	-0.081
Shunshine (hours)	Impact Coef. (D)	+7.13	+52.3	+17.3	+0.9	+221.0
	Correlative Coef. (rD)	+0.825**	+0.825**	+0.151	+0.171	+0.09
Humidity	Impact Coef. (E)	-351.1	-351.1	-37.0	-0.3	+16.9
	Correlative Coef. (rE)	-0.619*	-0.536	-0.377	-0.034	+0.179
Others	Impact Index (A)	+512.5	+17.1	-354.6	+135.1	+601.7

Proposed equation: $S = A + BX + CY + DZ + E_i$ in which, S: Production (kg/3,000 m^2 orchard at fruit bearing period), A: Undefined factors, $r = dxdy/\sqrt{\sum d^2x d^2y}$, *p = 0.95, **p = 0.99, Source: Compiled by the authors.

As a matter of fact, the area used for lychee production was rapidly increased during the 1998-2005 period (estimated to be more than 90,000 hectares), and has decreased gradually from then on (to approximately 60,000 hectares at present). It is however, mentioned that the application of advanced technologies resulted from the studies obtained by scientific institutions (research institutes, centers, universities etc.) that the remarkably quick increase in lychee yield has been recorded.

Up to now, the biggest areas under lychee cultivation are reported in Bac Giang province, with more than 18,300 hectares that produced nearly 180,000 tons in 2022 of which about 60,000 tons harvested from early cultivars and 120,000 tons came from the main season ones. Hai Duong province ranks the second biggest area under litchi cultivation, the area is estimated to be about 9,000 hectares with 60,000 fruit tons were harvested and the percentage of production produced from early cultivars is a little bit higher than Bac Giang (25,000 tons of 60,000 tons in total in 2022).

Apart from domestic consumption, mainly in Hanoi and Ho Chi Minh city, lychee fruit was exported to various countries over the world in which China, South Korea, Hong Kong, Japan, the Netherlands, the United States, are reported as good potential markets. It should be emphasized that lychee export both in terms of quantity and value (currencies) has been increasing

with time, e.g. from 600,000 USD in 2010 to 52.1 million USD in 2016. The quantity of lychee fruit exported in 2022 is estimated to be about 120,000 tons.

There are some reasons for the gradual continued increase of lychee yield and production in recent years, where results conducted from studies achieved from related scientific institutions, and the application of technical advances on a large scale should be considered as the main one.

Lychee production in the past was principally based on limited cultivars, namely the Thieu lychee, a traditional main season cultivar of lychee, harvested in June took a leading role, accounting for approximately 80 percent in terms of area under lychee cultivation within the whole country of Vietnam. A very small land area was used for the early cultivar, estimated to be less than 20 percent because of a limited number of early cultivar with high quality. In fact, the undiversified lychee variety gave a negative impact on the size of lychee production, presented by difficulties in harvesting lowering the quality of the product overall, and decreasing consumption.

Some early cultivars such as Binh Khe, Phuc Hoa, U Hong, U Trung, etc. were screened and selected by research institutions in collaboration with litchi growers and local authorities including agricultural services played an important part in expanding lychee production.

It must be realized that though the quality of early lychee cultivars is not as good as the main season ones in terms of sweetness as indicated by lower sugar contents, edible part percentage, and even flavor. The price of these cultivars products is usually remarkably higher (1.5 to nearly 2.0 times) than the Thieu Thanh Ha cultivar because of an early harvest (15 to 25 days earlier). The income given to lychee growers, therefore, is much better.

Moreover, ecological conditions, meteorological factors first required by early cultivars of lychee for flower initiation are not as serious as the main season ones. It means that the situation of irregular bearing phenomenon regarded as a decisive factor for lychee production generally and lychee main season cultivars particularly are not usually reported in early ones.

Of the early cultivars selected for production in the North of Vietnam, the PH40 cultivar has a lot of advantages in terms of the growth, yield, fruit quality and adaptability to the different ecological conditions. Some main characteristics of this cultivar related to its productivity and product quality are presented in Table 2 [5].

Table 2. Some main characteristics of the PH40 cultivar in different orchards in various locations.

Items orchards	Fruit setting ratio	No. of fruit/ a bunch	Mean of fruit weight (g)	No.of fruit bunch/ a tree	Yield (tons/ha)
1	0.51	5.4	52.1	141.1	15.9
2	0.71	6.1	52.8	139.2	17.9
3	0.72	6.8	53.0	142.0	20.5
4	0.72	7.1	53.1	140.9	21.3
5	0.48	5.1	46.2	146.8	13.8

Source: Compiled by the authors.

With the newly screened and selected from widely established germplasm of lychee on a large scale, the study has also focussed on the cultivating technologies to be introduced and applied in lychee production that significantly contributed to improving the yield and quality of the product.

Various results achieved from the research into lychee orchard management in terms of fertilizer application, training and pruning techniques, growth regulator utilization, IPM and ICM technologies, etc. have been introduced in production and gave impact not only in stabilizing lychee productivity but also in improving lychee quality as well.

Of the newly advanced technologies introduced and applied effectively in lychee production, the technique of branch girdling was regarded as a key practice to improve the flower bud differentiation of the lychee tree resulting in overcoming the phenomenon called “bearing irregular fruit” mentioned in the above part. It becomes more important in case of unsuitable climate condition for lychee flower bud initiation.

One of the results conducted from the study on a newly introduced cultivar of lychee named “PH40”, it showed that the double application of the timely girdling technique (implemented in mid-October for the first and repeated in 15 days after the first) had changed the ratio of total carbohydrate and total nitrogen. The

Table 3. The impact of girdling technique at different levels on the C/N ratio in leaves and flowering ability of PH40 lychee cultivar.

Level of girdling	Total carbohydrate (%)	Total nitrogen (%)	C/N	Percentage of trees flowered (%)
Control (No girdling)	1.14±0.21	1.61±0.33	0.73±0.15	70.6
Slightly girdled*	1.45±0.31	1.58±0.30	0.95±0.29	80.2
Averagely girdled**	1.72±0.26	1.60±0.19	1.08±0.12	100.0
Heavily girdled***	1.81±0.24	1.63±0.19	1.13±0.26	100.0

*A small ring formed; **A 2-3 mm width ring formed; ***A 4-5 mm width ring formed. Source: Compiled by the authors.

value of approximately 1 of this ratio was considered to be appropriate for lycheeflower bud differentiation. By doing that, the situation of the flowering process of lychee was significantly improved, lychee trees could flower even in unsuitable climatic conditions.

Table 3 summarised the impact of girdling technology at different levels implemented on "PH40" lychee cultivar.

It is also emphasized that, the results achieved from different research institutions (institutes, universities, centers, companies) were then over-all combined and applied in large scale in the form of technical demonstrations of lychee production with the assistance of local authorities and extension services in particular. The demonstrations proved practically the achievements obtained from the studies from which lychee growers could come to see and learn new technologies which could be applied in their orchards.

Table 4 summarised the main successes of the lychee technical demonstration where advanced technologies were accordingly applied.

Results of the study also showed that the income obtained from the technical demonstration was much higher than normal orchards (553.03 million VND/ha compared to 330.40 million VND/ha). It proved that the application of overall advanced technologies gave a good impact to large scale of lychee production resulted in significantly improving living standard of the growers.

Table 4. Results reported from a technical demonstration of PH40 lychee cultivar in 2020.

No.	Items recorded	Normal orchard	Technical demonstration
1	Percentage of trees flowered (%)	60	100
2	Number of fruit bunches/a tree	180	185
3	Number of fruit/a bunch	5.8	6.5
4	Fruit weight (g)	51.0	53.2
5	Theoretical/Estimated yield (tons/ha)	15.97	19.19
6	Harvested yield (tons/ha)	15.65	18.90

Source: Compiled by the authors.

2.2. Temperate fruit crops

Lychee fruits that have been dealt with in the above-mentioned part, temperate fruit crops are considered as the advantageous fruits in the North of Vietnam whereas very limited area in central highland was used for temperate fruits development targeted for local consumption.

Temperate fruits with chilling requirement: It is understood that, the development of temperate fruits as commercial crops is closely related to ecological conditions in which lower atmosphere temperature in the late autumn to winter period calculated by chilling hours (CU) plays a very important role [3, 6-8] (Table 5).

Meteorological data were then presented in the form of a diagram (Fig. 1):

Development of temperate fruits in some Northern mountainous provinces in recent years: Aimed to understand the development of temperate fruit trees in relation to climatic conditions, several locations that

Table 5. Synthesis of chilling unit accumulation (CU) in some areas.

Locations	2001	2002	2003	2004	2005	2006	2007	2008	2009	Means
Moc Chau	167.1	303.1	350.8	253.0	280.6	220.9	340.2	316.3	395.0	291.9
Bac Yen	82.2	198.8	221.0	142.1	196.0	134.8	212.5	207.0	253.0	183.0
Phu Yen	-15.9	75.8	95.4	40.6	84.4	22.9	86.6	104.4	135.0	69.9
Co Noi	48.6	185.3	180.1	106.7	144.6	123.0	165.0	169.7	253.0	152.9
Sin Ho	309.7	650.7	463.7	430.5	406.6	398.9	503.4	410.5	588.8	462.5
Tam Duong	134.8	250.0	214.5	148.8	265.1	185.3	229.5	185.3	296.6	211.9
Sa Pa	485.5	662.1	741.4	628.3	633.9	601.4	974.0	650.7	915.0	699.1
Bac Ha	259.0	336.8	379.9	309.7	383.7	309.7	410.5	446.9	508.1	371.6
Yen Bai	28.7	99.9	120.6	118.2	142.1	56.8	140.0	188.0	177.4	119.1
Luc Yen	21.0	99.9	113.6	99.9	137.2	73.6	152.0	185.3	191.0	119.3
Mu Cang Chai	127.1	223.8	235.3	204.2	241.1	182.7	198.8	177.4	383.7	219.3
Nghia Lo	22.7	99.9	120.6	80.1	120.6	67.3	130.0	159.5	180.1	109.0
Ham Yen	28.6	82.2	109.0	95.4	132.4	54.8	125.3	174.8	190.7	110.4
Ha Giang	44.6	86.6	111.3	99.9	147.0	67.3	157.0	174.8	198.8	120.8
Bac Quang	26.8	93.2	111.3	95.4	120.6	58.9	139.7	174.8	177.4	110.9
Cao Bang	113.6	172/3	111.3	142.1	259.0	95.4	244.3	340.2	256.0	192.7
Trung Khanh	212.5	293.3	347.2	323.1	351.2	244.3	402.7	575.5	395.3	349.5
Bac Kan	61.0	113.6	157.0	137.2	172.3	84.4	170.0	232.4	215.3	149.2
Ngan Son	182.7	259.0	253.0	280.6	233.3	190.7	350.8	451.1	402.7	289.3
Bao Lac	15.7	118.2	149.5	104.4	159.5	75.8	193.3	209.7	212.5	152.9
Dinh Hoa	36.6	97.7	147.0	120.6	152.0	56.9	147.0	207.0	196.4	129.0
Lang Son	152.0	209.2	241.1	226.6	303.1	165.0	271.2	442.7	313.0	258.2
That Khe	123.0	164.6	221.0	188.0	274.3	128.0	247.8	383.7	265.1	221.7
Son Dong	146.6	99.9	95.4	84.4	137.2	73.6	113.6	209.7	177.4	126.4
Luc Ngan	34.6	93.2	139.7	113.3	149.5	58.9	125.3	232.4	177.4	124.9
Tien Yen	73.6	123.0	169.7	127.7	169.7	84.4	149.5	215.3	182.7	144.0
Da Lat	77.9	102.2	95.4	-55.0	109.0	67.2	75.8	77.9	147.0	77.5
Bao Loc	-60.0	-59.9	-59.9	-38.4	-48.5	-72.6	-58.3	-80.4	-58.3	-59.6

Using Prochill software, referred to George - Nissen formula:$Y = a+b/x^{½}$. Source: Compiled by the authors.

had sufficient chilling accumulation for flower initiation of several temperate fruit varieties were selected for sampling. The figures were summarised in Tables 6-8.

In all 3 locations, the area and total output tended to increase significantly in recent years, especially in Ha Giang province (Table 6) and districts such as Moc Chau (Table 7) and Bac Ha (Table 8), in which production of pear trees in all 3 locations, plum trees and peach trees in Ha Giang province has increased quite considerably in the last 3 or 4 years [9, 10].

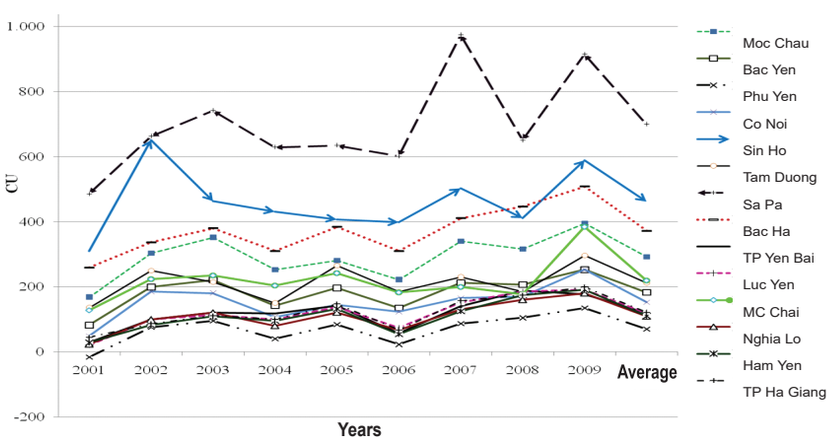

Fig. 1. Diagram of chilling unit presented by hour numbers in some locations in Northen mountainous provinces. Source: Compiled by the authors.

Table 6. Area and production of temperate fruits in Ha Giang province.

No.	Species	2016		2017		2018		2019	
		Area (ha)	*Total yield (ton)*	*Area (ha)*	*Total yield (ton)*	*Area (ha)*	*Total yield (ton)*	*Area (ha)*	*Total yield (ton)*
1	Pear	724.0	2,103.8	946.5	2,300.5	980.5	2,517.9	1,282.7	4,966.6
2	Plum, peach	1,148.9	1,973.8	1,147.9	1,839.4	1,183.8	2,044.0	1,920.1	4,561.5
3	Persimmon					445.9	523.2		

Source: Compiled by the authors.

Table 7. Area and production of temperate fruits in Moc Chau district, Son La province.

No.	Species	2016		2017		2018	
		Area (ha)	*Total yield (ton)*	*Area (ha)*	*Total yield (ton)*	*Area (ha)*	*Total yield (ton)*
1	Plum	1,413.0	13,273.0	1,439.0	11,299.0	1,951.0	16,700.0
2	Persimmon	19,0	465,0	41,0	442,0	45,0	464,0
3	Peach	42,0	175,0	48,0	184,0	58,0	197,0
4	Pear	133,0	822,0	115,0	693,0	105,0	499,0
	Sum	1,607.0	14,735.0	1,643.0	12,618.0	2,159.0	17,860.0

Source: Compiled by the authors.

Table 8. Area of some temperate fruits in Bac Ha district, Lao Cai province until 2019.

Year	Area of land (ha)	Area of temperate fruit trees (ha)	% in area of land	Temperate fruit species				
				Peach	*Persimmon*	*Pear*	*Plum*	*Others*
2010	-	685	-	60	23	95	477	30
2011	-	840	-	80	23	135	572	30
2012	-	916	-	93	23	185	585	30
2013	-	983	-	98	23	247	585	30
2014	-	1,008	-	98	23	272	585	30
2015	-	1,035	-	98	23	286	593	35
2016	-	1,042	-	98	23	286	600	35
2017	-	1,092	-	105	23	286	643	35
2018	-	1,167	-	115	23	300	693	36
2019	4,6126	1,207	67.5	120	23	315	712	37

Source: Compiled by the authors.

2.3. Chilling unit in relation to the issue of distribution and planning of temperate fruit cultivation

The map of the distribution of temperate fruit trees in the Northern mountainous region, as shown in Fig. 2 is made using the results of the survey conducted in 2019 and 2020, referencing documents from local management agencies.

Generally speaking, Northern mountainous provinces have big potential for the development of temperate fruits, which would be a good way to properly utilize the unemployed land availability in terms of limiting soil erosion and improving the living standard of local people, particularly poor farmers in remote locations. It is necessary to mention that the production of temperate fruits is firstly targeted

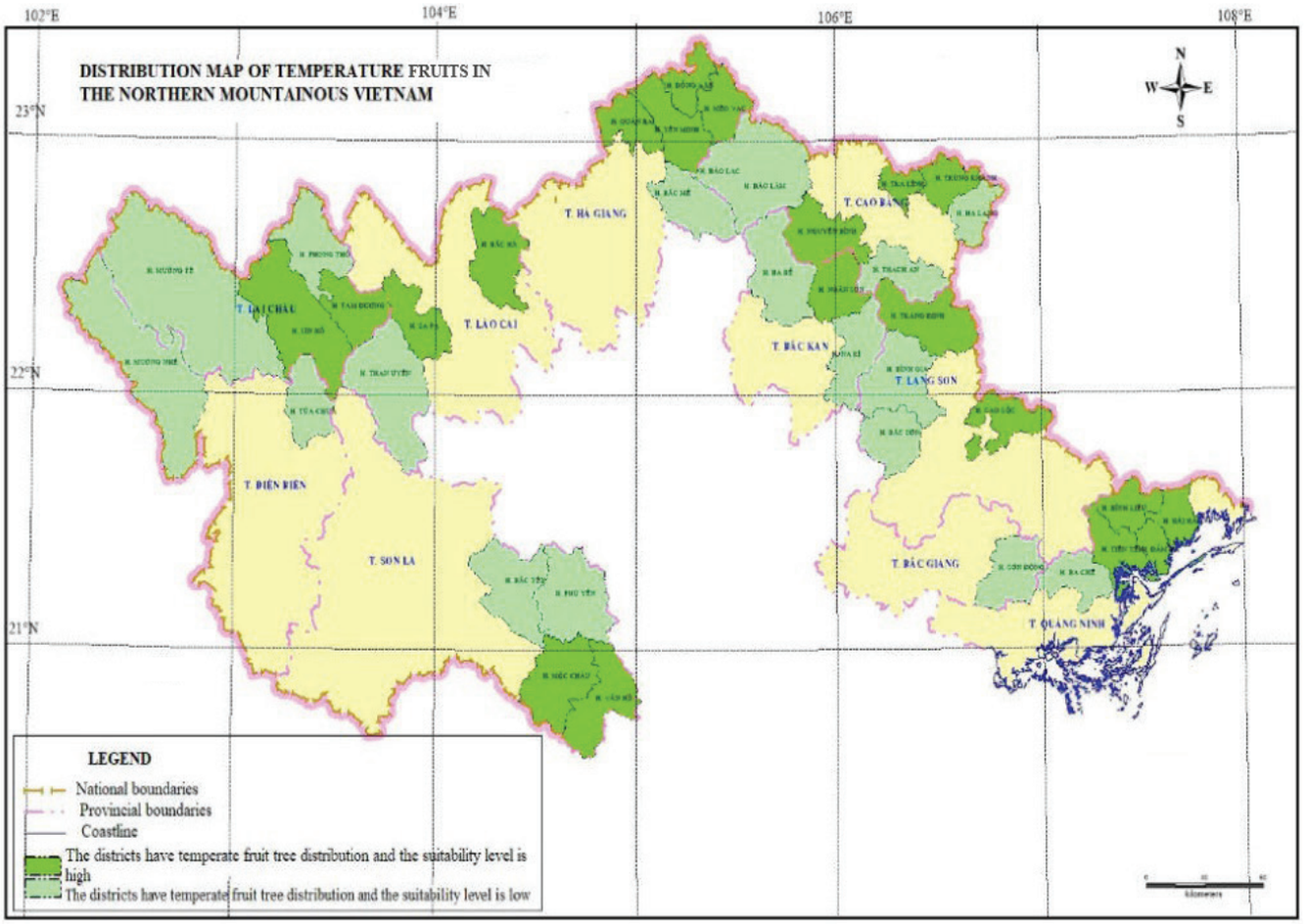

Fig. 2. Projection of temperate fruits development based on CU values calculated from various locations in the North of Vietnam. Source: Compiled by the authors.

to decrease fruit products, mainly temperate ones imported from abroad. This was estimated to be nearly one million USD annually. The study on temperate fruits aims to create and screen good varieties and cultivating technologies. Therefore, this topic should be paid more attention to in the near future.

2.4. Other fruit crops

Apart from lychee and temperate fruits discussed above, some other species of fruit crops such as bananas, oranges, pomelo, etc. are also considered to have some advantages when grown in the North of Vietnam in terms of product quality and the availability of land and labor for large scale fruit production.

Bananas: The land area under bananas cultivation in the North of Vietnam is estimated to be 66,000 hectares accounting for nearly 46% of the area and 52% of production in the whole country. The yield of bananas in the Northern provinces is about 32% higher than the Southern provinces. In addition, the quality of bananas especially cultivars belonging to the Cavendish group planted in the North is usually better than the same variety cultivated in the South indicated by good flavor, attractive appearances mainly because of light quality and the fluctuation of daytime and nighttime temperature.

One of the successes of the study on bananas is selecting a good cultivar from the Cavendish group named “Tieu Hong”, characterized by healthy growth, quite a high yield (45-50 tons/ha), well shaped bunch (cylinder form), attractive color (shine yellow fruit peel and flesh), good flavor. This meets all the standards for export, firstly exported to China. This banana cultivar when cultivated with advanced technologies conducted by research agencies such as fertilizer application, newly applied irrigation, IPM and ICM

Table 9. The situation of "Panama" disease observed on some main banana varieties cultivated in the North.

Banana cultivars	Place of origin	Locations observed*	Planting materials	Affected plant percentage (%)
Tieu* Hong	Ha Nam	Ba Vi - Hanoi	Suckers	29.33
Tieu* Quang Nam	Quang Nam	Dai Loc - Quang Nam	Suckers	33.33
Tieu* Lao Cai	China	Muong Khuong - Lao Cai	*In-vitro*	28.00
Tay** Hung Yen	Hung Yen	Khoai Chau - Hung Yen	*In-vitro*	44.67
Tay** Quang Tri	Quang Tri	Huong Hoa - Quang Tri	Suckers	40.67
Tay**Thai Lan	Thailand	Tu Ky - Hai Duong	Suckers	0,00

**M. cavendishii* Lamb (Cavendish group); ***M. sapientum* Lamb. Source: Compiled by the authors.

utilization, etc. produced good quality products that were easily consumed at a high price (compared to the other cultivars planted at the same time and same location). Good income is given to banana growers in different locations (estimated of 150 million - 180 million VND/ha) it is also regarded as one of the advantages of the cultivar.

The problem raised recently for banana production is the presence of the so-called "Panama wilt" with yellow wilt leaf symptoms caused by *Fusarium oxysporum* f. sp. Cubense (FOC) which has never been observed in the Cavendish bananas plantations in Vietnam before.

Although no official data resulted from the observation of this disease was officially reported, investigations done by research institutions showed that the disease was available in almost all traditional areas of the cavendish bananas cultivation in the North, says Phu Tho, Vinh Phuc, Ha Noi, Hung Yen to the South, e.g. Dong Nai, Binh Duong, Tien Giang, and seriously affected the growth and productivity of banana table (Table 9). It was also reported that affected banana plants could not grow well and almost no fruit bunch was harvested [11, 12].

With the big effort of scientists from differently related scientific fields, a newly released Cavendish banana cultivar coded GL3-5 was created by somaclonal variation method and introduced in a small scale banana production for evaluation. Results conducted from the study showed that GL3-5 when introduced in various locations combined accordingly with advanced technologies such as fertilizer application, irrigation, IPM utilization, etc. It was reported to be promising indicated by healthy growth, no yellow wilt symptoms, high yield (more than 40 tons/ha), attractive appearances, very slight affected by "Panama wilt" disease particularly. Data given in Table 10 was recorded in the technical demonstrations of GL3-5 cultivar, compared to the normal gardens where local Cavendish cultivars (Tieu Hong in Hung Yen, Tieu Quang Tri in Quang Tri) or introduced Cavendish cultivars (William cultivar in Lao Cai location) [11, 13].

Table 10. Percentage of Cavendish banana plants affected by bunchy top (BBTV) and yellow wilt (Panama) diseases in different plantations.

Locations	For BBTV		For Panama	
	2018	*2019*	*2018*	*2019*
Hung Yen				
- Normal gardens	1.8	2.5	21.4	20.2
- Tec. Demonstration	2.3	1.9	0	0
Lao Cai				
- Normal gardens	1.6	2.7	15.2	13.1
- Tec. Demonstration	2.1	1.9	0	0
Quang Tri				
- Normal gardens	2.5	3.1	0	0
- Tec. Demonstration	1.0	1.5	0	0

Source: Compiled by the authors.

Oranges and pomelo: The area used for oranges and pomelo production in the Northern provinces (54.5% for oranges and 48.9% for pomelo of the whole country) is equivalent to the South where some famous citrus cultivars had been traditionally

Table 11. Harvesting time periods of oranges and pomelo in the North of Vietnam.

Species	Early harvested*	Main season harvested**	Late harvested***
Oranges	CS1, BH, CT9, CT36	"Sanh", "Xa Doai", "Van Du"...	V2…
Pomelo	"Hong Quang Tien", "Phuc Trach", "Hoang", "Dao", "Chua dau tom", etc.	"Do" (red color), "Da Xanh", "Dai Minh", "Doan Hung"…	"Dien"

*Harvested from September to early October; **Harvested from mid-October to November; ***Harvested from December to next January. Source: Compiled by the authors.

cultivated, particularly the seedless varieties such as Da Xanh and Nam Roi cultivars (Table 11). Though oranges and pomelo production is mainly targeted for domestic consumption, lots of local citrus cultivars have advantages presented by good flavor and attractive appearances due to light quality and temperature fluctuation of day time and nighttime in growing locations. The main achievements conducted from the study on oranges and pomelo can be summarised as follows:

- A diversified set of promising citrus cultivars with different harvest time periods have been accordingly selected, from which elite trees of each cultivar were screened to be used as good planting material for multiplication.

- A numerous quantity of materials used for the breeding programme from different methods (crossing - including diploid and tetraploid combinations, mutation treatment, male sterility utilization) are now under evaluation and selection.

- Intensive cultivating technologies for oranges and pomelo orchard management have been continuously improved resulting in stably increasing the yield and product quality in the whole region generally.

Sugar apple/Sweet sop: Though the area cultivated with sugar apples in the North is quite limited, the quality of this fruit is highly appreciated by consumers, especially when grown in alkali affected soil and alpine soil in upland zones of Northern provinces such as Lang Son, Bac Giang, Quang Ninh, etc. [9]. Concerning the study on sugar apple, two main issues have been focussed and its results were successfully introduced and applied on a large scale.

Firstly, the utilization of training and pruning technologies focused mainly on time of practice and the length of shoots remained to produce off-season fruit harvest. By doing that, the harvest duration of sugar apple could be prolonged by 3 to 4 months instead of nearly 1 month, resulting in an increase income of growers was also recorded.

Secondly, the establishment of intensive demonstrations of sugar apple by applying technical advances resulting from different studies such as fertilizer application, training and pruning, supplemented pollination, fruit package, mulching, IPM utilization, etc. in sugar apple orchard management. Results showed that better situation of orchard growth and yield and more income earned by local growers was clearly recognised (Table 12).

3. Policies related and its impact on the development of fruit crops recently

The development and sustainability of fruit production in recent years resulted from various reasons, the policies issued by the Government and guided by the Ministry of Agriculture and Rural Development played an important role.

On the basis of the master plan of fruit, vegetable, flower and ornamental crops development approved by the government detailed in the agricultural crop

Table 12. Productivity of sugar apple technical demonstration.

Orchard types	Average No. of fruit/tree	Fruit weight (g)	Theoretic yield (kg/tree)	Yield harvested (kg/tree)	Comparison (%)
Demonstration	70.7	228.7	16.17	15.4	149.5
Normal orchard	58.0	193.8	11.24	10.3	100.0
CV %		12.3		8.2	
$LSD_{0.05}$		10.9		1.1	

Source: Compiled by the authors.

variety program, numerous decisions and guidance at ministerial levels have been issued and delivered in which fruit production was regarded as one of the key sectors for strengthening national economy in general and for exportation in particular.

In the scope of policies concerning, the problems faced by fruit production on a large scale were dealt with and proper solutions were also accordingly proposed in which land utilization, credit loans used for fruit development, the participation of business enterprises, the expenditure used for research, the improvement of grass rot conditions have been paid great attention to.

Concerning the study on fruit crops, various policies and orientations concerned had been delivered and guided by the Ministry of Agriculture and Rural Development in which the following issues were accordingly focused:

- The research into fruit varietal programs must be prioritized, of which, locally specific and advantageous fruit cultivars should be emphasized. Elite individual trees of fruit-promising cultivars would then be carefully evaluated and screened as good mothers for multi-propagation programs.

- Establishing the system of fruit seedling/newly grafted tree production with high quality and disease-free planting materials for new plantations and varietal replaced cultivars (Top-working technology).

- Strengthening the synchronized application of technical advances in large-scale fruit production with proper approaches:

+ Technical advances applied in each fruit crop should be accordingly grouped as a synchronized set of techniques (a technological KIT) and introduced in fruit production with two levels: high technology and advanced one suitably applied in local conditions.

+ Fruit research institutions (institutes, centers, universities, etc.) should be closely linked in fruit production chances and be responsible for technical transfer organization.

- The study and transfer of advanced technologies of leading fruit crops cultivated in concentrated areas under climate change circumstance should be prioritized in which cultivating techniques in sloped land, selecting proper rootstocks resistant to serious diseases and unsuitable conditions, training and pruning techniques utilizing organic fertilizers, off-season fruit production technologies… must be considered.

- Great attention and sufficient investment should be focused in the study on post-harvest including processing of fruits targeted in decreasing the pressure of the fresh fruit consumption, widening the markets and improving the quality and added value of the products.

In accordance with the master plan for fruit development approved by the Government, numerous decisions, resolutions, and circulars concerned had been delivered and instructed by the Ministry of Agriculture and Rural Development in which the following subjects were strongly focused:

- To strengthen the study on market forecast especially the world market from which fruit production should be accordingly adjusted.

- To widely disseminate newly advanced technologies for fruit cultivation, especially in the condition of climate changes into fruit growers and fruit production companies.

- To strongly promote the training courses of new technologies to fruit producers (farmers and processors) including training of trainer ones (TOT) in which high techniques aimed at improving fruit quality should be paid great attention to.

- To accordingly boost the solutions for mechanizing fruit production firstly targeted land preparation, product harvesting, equipment manufacturing used for fruit processing, etc.

- To reconsider national regulations and standards related to fruit production in accordance with international ones and suitably apply them to the conditions of Vietnam.

These above-mentioned policies issued by the Government and direction guided by the Ministry of Agriculture and Rural Development have promptly promoted fruit development in the whole country in general and the Northern provinces in particular in terms of total production, product quality and income benefited as well.

In some provinces, the area under fruit cultivation and fruit production remarkably increased, resulting in improved living standards for fruit growers and the local economy. Let's take Son La province as

an example, the area used for fruit production in 2022 was estimated to be about 85,000 hectares, and nearly doubled compared to 2017 and the total fruit production was 210.5% higher than in 2017. In addition, numerous locations where specific fruits were produced have been established and developed with time such as longan production in Song Ma district, sweet apple production in Yen Chau district, and plum production in Moc Chau one, etc. Some advantageous fruits produced in Son La province have been exported to China, the United States, the United Kingdom, Australia, and other EU countries with a value of about 20 thousand USD annually.

Under the newly issued policies and instructions, a lot of advanced technologies have been effectively applied in large-scale fruit production in various locations, significantly contributing to the improved fruit yield, quality and value of exportation as well.

Apart from new varieties and technical advantages introduced and applied successfully in fruit production, numerous results conducted in the studies on post-harvest and processing of fruit products were considered as one of the main factors for the rapid development of fruit production in which the utilization of naturally originated substances in retarding fruit ripening process, prolonging harvest time duration and decreasing fruit drop ratio and the use of MAP membrane in fruit packaging were applied.

CRediT author statement

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COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

REFERENCES

[1] D.S. An (2016), *A Study on Selection and Development of Temperate Fruits in Some Northern Mountainous Locations*, Master scientific Thesis, Vietnam National University of Agriculture (in Vietnamese).

[2] V.M. Hai, N.T. Yen, L.N. Lan, et al. (2016), *Primary Evaluation of Adaptability of Introduced Temperate Fruits from Taiwan in The Northern Mountainous Region*, International cooperation project report, Vietnam Academy of Agricultural Sciences (VAAS).

[3] V.M. Hai, B.Q. Dang, L.Q. Thanh, et al. (2023), *Chilling Unit in Relationship with The Development of Temperate Fruits in Northern Mountainous Provinces of Vietnam*, Vietnam Academy of Agricultural Sciences.

[4] D.D. Ca, V.V. Hung, D.Q. Nghi, et al. (2010), *Application of Advanced Technologies for Improving The Yield and Quality of Sweetsop in Lang Son Province*, Master scientific Thesis, Vietnam National University of Agriculture (in Vietnamese).

[5] H.Q. Thuong, D.H. Long, D.Q. Huy, et al. (2020), *Completion of Technological Procedures on Cultivation and Multiplication of PH40 Lychee Cultivar*, Final report of the State project (in Vietnamese).

[6] L.D. Khanh, T.T. Toan (2007), *A Study on The Integrated Technologies for Development of Some Temperate Fruits (Plum, Persimmon, Peach) of High Quality in The Northern Mountainous Provinces*, Final report of the State scientific Thesis in 2004-2007 period (in Vietnamese).

[7] B.L. Topp, W.B. Sherman, M.C.B (2008), *Low Chill Cultivar Development The Peach Botany, Produce and Use*, CAB International, Wallingford, UK, DOI: 10.1079/9781845933869.0106, accessed 5 May 2023.

[8] T.T. Toan, L.D. Khanh, N.T. Hien, et al. (2015), *Final Report on Pilot Production of Early Peach Cultivar DCS1 in Son La and Lai Chau*, Ministry of Agriculture and Rural Development (in Vietnamese).

[9] V.M. Hai (2010), *The Irregular Bearing Situation in Fruit Crops and The Way to Overcome This Phenomenon*, Agriculture Publishing House, 110pp.

[10] H.Q. Thuong, H.T. Cung, N.T. Ngan, et al. (2016), *Exploitation and Development of Hac Tri, Dien Bien and Quan Ba Persimmon Cultivars*, Master scientific Thesis, Vietnam National University of Agriculture (in Vietnamese).

[11] S. Saechow, A. Thammasittirong, S.N.R. Thammasittirong (2017), "The potential of *Bacillus subtilis* BAS114 for *in vitro* biocontrol of *Fusarium oxysporum"*, *Advances in Environmental Biology*, **11(1),** pp.46-51**.**

[12] T.N. Hung, N.Q. Hung, N.V. Dzung, et al. (2018), "First report of fusarium wilt on cavendish bananas caused by *Fusarium oxysporum* f. sp. *cubense* tropical race 4 (VCG 01213/16) in Vietnam", *APS Journals*, **102(2)**, DOI: 10.1094/PDIS-08-17-1140-PDN.

[13] N.V. Dzung, V.V. Thang, N.V. Nghiem, et al. (2019), *A Study on The Varietal Selection of Bananas of High Yield Good Quality and Tolerant to Panamas Disease*, Final report of the State scientific Thesis.