

MINISTRY OF EDUCATION AND TRAINING
THAI NGUYEN UNIVERSITY

NGUYEN HUU THO

**STUDY ON AGRO-BIOLOGICAL CHARACTERISTICS
AND SOME CULTIVATION TECHNIQUES FOR DIEN PUMMELO
CULTIVAR (*CITRUS GRANDIS*) IN THAI NGUYEN PROVINCE**

**SUMMARY OF DOCTORAL DISSERTATION
OF PHILOSOPHY IN AGRICULTURE**

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Supervisors: **1. Assoc. Prof. Ngo Xuan Binh, PhD.**
 2. Prof. Nguyen The Dang, PhD.

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**LIST OF PUBLICATION RELATED TO PH.D.
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- 1. Nguyễn Hữu Thọ, Ngô Xuân Bình, Hoàng Thị Thủy, Lê Tiên Hùng, Akira Wakana (2014),** “Self-incompatibility in Pumelo (*Citrus Grandis* L. Osbeck) with focus on Vietnamese Cultivars with and without Parthenocarpy, *J. Fac. Agri. Kyushu Uni.*, 59, pp. 65-70.
- 2. Nguyễn Hữu Thọ, Hoàng Thị Thủy, Ngô Xuân Bình, (2014),** “Nghiên cứu thực trạng sản xuất bưởi Diễn tại tỉnh Thái Nguyên”, *Tạp chí Khoa học và công nghệ, Đại học Thái Nguyên*, tập 130, số 16, tr.95-100.
- 3. Nguyễn Hữu Thọ, Hoàng Thị Thủy, Lê Tiên Hùng, Ngô Xuân Bình, (2014),** “Kết quả nghiên cứu mối quan hệ giữa tuổi cành mẹ và sinh trưởng cành quả tới năng suất của cây bưởi Diễn (*C. grandis*)”, *Tạp chí Nông nghiệp và Phát triển Nông thôn, số 1, tr.44-49.*
- 4. Nguyễn Hữu Thọ, Ngô Xuân Bình, Hoàng Thị Thủy, Lê Tiên Hùng (2011),** “Nghiên cứu quá trình sinh sản hữu tính liên quan đến khả năng đậu quả ở cây bưởi Phúc Trạch (*Citrus grandis*).”, *Tạp chí Nông nghiệp & PTNT*, số 19, tr. 78-83.
- 5. Nguyễn Hữu Thọ, Bùi Thanh Phương, Nguyễn Thị Lan Hương, Ngô Xuân Bình (2010),** “Nghiên cứu một số đặc điểm sinh học của một số dòng giống bưởi tại Thái Nguyên”, *Tạp chí Nông nghiệp & PTNT*, số 11, tr. 88-93.

INTRODUCTION

1. Rationale of the study

Pommelos (*Citrus grandis*) is amongst the most popular cultivated citrus crops in Vietnam and in other Asian countries such as China, Indian, Thailand, Malaysia, and the Philippines. The crop has brought about high economic value for producers (Nguyễn Quỳnh Hoa, 2010). Currently, fruit crops are considered as the important components in restructuring cropping patterns, improving economic efficiency and agro-ecosystems, particularly for the northern midland and mountainous provinces of Vietnam.

Thai Nguyen is a midland province in the northern region. The province has high potential for development of fruit crops, including citrus crops. Dien cultivar (*Citrus grandis* var. “Dien”) is amongst the important crop, which is currently interested and being developed by the local governments and farmers. However, its productivity and quality are currently low that do not meet market demands (Hoàng Văn Việt, 2014).

The Dien pummelo is a valuable cultivar which is mainly cultivated in Phu Dien and Phu Minh communes of Tu Liem district, Hanoi. Previous studies have so far been limited to external morphological characteristics of the crop and fruits. To develop technical protocols for improving its productivity and quality, more in-depth studies regarding its agronomic and biological characteristics are essential. The studies would provide a basis for further research on cultivation techniques to improve its yield and quality.

Therefore, conducting the “*study on agro-biological characteristics and some cultivation techniques for Dien pummelo cultivar (Citrus grandis) in Thai Nguyen province*” would be rational, which has a number of practical implications.

2. Overall research objective

- Characterise agronomic and biological characteristics of Dien cultivar in Thai Nguyen and determine some technical measures to improve productivity and quality of the variety in the research area.

3. Specific objectives

- To evaluate the current situation of fruit production, particularly cultivation of Dien variety in Thai Nguyen, and define barriers to pummelo production in the research area;

- To study the agronomic and biological characteristics of Dien variety cultivated in Thai Nguyen.

- To study technical methods to improve its productivity and quality in Thai Nguyen.

4. Scientific and practical significance of the research

- Outcomes of this study will provide as the basis for forthcoming research on technical methods to improve productivity and quality of Dien pummelo variety.

5. New scientific findings

- Studies on bud formation relationship would enable to explain the irregular fruiting of fruit crops in general and of pummelo in particular.

- Research into effects of C/N ratios on fruit productivity would help to develop appropriate techniques to improve flowering and fruitset ratios, and thus improved pummelo yield.

- Understanding of pollination and fertilisation mechanisms in Dien cultivar helps to explain the formation of seedless fruits in citrus crops in general and in Dien cultivar in particular.

- Outcomes of this study would offer an opportunity to select appropriate technical methods for improving productivity and quality of Dien variety in Thai Nguyen.

Chapter 1. LITERATURE REVIEW

Pummelos are mainly cultivated in Asian nations, including China, Philippines, Thailand and Vietnam. Pummelo species in Vietnam are very diverse with highly quality varieties and potentials for export and domestic consumption such as Nam Roi, Da Xanh, and Dien pummelo cultivars. Due to a number of reasons, several pummelo varieties have been degraded in their quality and yields *chất* (Đào Thanh Vân and Ngô Xuân Bình, 2003). In-depth studies are therefore needed to determine and address the barriers.

Environmental factors, particularly temperature, humidity, play very decisive roles in regulating flowering time, fertilisation, and fruitset of citrus crops and pummelos (Pinhas, 1996). This drives new research

directions to promote and regulate plant growth, flowering, pollination and fertilisation to reduce detrimental environmental impacts on Dien pummelo in Thai Nguyen.

Foliar fertilizers, particularly ones that contain micro-elements and growth regulator such as GA₃, are very useful foster flowering, fruitset, and improve fruit appearance and quality. They can also reduce number of seeds if they are sprayed at suitable times (Đỗ Đình Ca, 2006). However, the effects depend on each specific variety. Those should be tested on Dien variety to evaluate possible impacts on fruit productivity and quality.

Pruning aims at balancing between vegetative and reproductive growth of crops. The technique can reduce pest occurrence, while improving productivity, fruit appearance and regulating a desired plant size (Vũ Việt Hưng, 2011). Pruning is even more effective when it is combined with other technical measures such as watering and fertilisation. However, inadequate pruning often induces negative impacts on plant growth. A pruning protocol can only adopted to a specific variety in a certain ecological condition. Therefore, a specific pruning technique should be studied for Dien variety in Thai Nguyen.

Girdling is a technique that modifies C/N ratios to regulate flowering and fruitset on fruit crops (Trần Văn Hậu, 2009). The technique has been successfully applied for several famous Chinese pummelo varieties such as Quan Khe, Sa Dien (Cục nông nghiệp Quảng Tây, 2009). Therefore, testing this technique on Dien variety is necessary to evaluate possible impacts on flowering and fruitset. Due the climatic condition in Thai Nguyen province, girdling should be recommended to be carried out at the end of January or early February for effective fruiting.

Supplementary pollination is necessary for citrus crops in general and for pummelos in particular. The technique is essential for improving fruitset and fruit size. Efficacy of the method is dependent on varieties and specific ecological regions (Suwanapong, 1991). To have accurate conclusions for the selected variety in Thai Nguyen, a comprehensive study is therefore needed. A single technique (pruning, fertilisation, watering, or supplementary pollination...) would be more effective when it is integrated in a comprehensive protocol. For these reasons, developing a comprehensive method that integrates all specific techniques is essential.

CHAPTER 2. MATERIALS AND METHODS

2.1. Located and materials research

2.1.1. Located research

The experiment was carried out in 6 year old of Dien grapefruit cultivar at Tuc Tranh commune, Phu luong district, Thai Nguyen province. Other experiment was conducted in the Lab of Thai Nguyen University Agriculture and forestry

2.1.2. Materials research

- The present study was conducted on 6 years old Dien grapefruit cultivar on sour grapefruit grafted at Phu Dien commune, Tu Liem district, Ha Noi

- Others materials: Gibberellin (GA₃) made of Fermentate (German) was used in this study

- Pollen source: Pollen source was collected from Dien, Da Xanh, Nam Roi, Phuotrach grapefruit and Duong Canh orange cultivars

- Bagging materials: Bagging materials made in Japan

2.2. Research contents

Content 1: Investigation, evaluate of grapefruit production to identified the limit factor in grapefruit production at Thai Nguyen

Content 2: To study the agronomic characteristics of Dien grapefruit cultivars at Thai Nguyen

Content 3: To study the effect of some techniques on fruit growth, yield and quality of Dien Grapefruit at Thai Nguyen

2.3. Research methodology

2.3.1. Method research of Investigation, evaluate of grapefruit production to identified the limit factor in grapefruit production at Thai Nguyen

Primary data collection method: The primary data was collected from reports, strategy development, and statistical data

Second data collection method: Question survey was used to interview smallholders planted Dien grapefruit at Thai Nguyen province

Data collection: area, yield and production of Dien grapefruit every year was collected. The limit factors in grapefruit production at smallholders in Thai Nguyen was recorded

2.3.2. Method research of agronomic characteristics of Dien grapefruit cultivars at Thai Nguyen

2.3.2.1. Experiment design

The experiment was conducted at Dien grapefruit orchard from 2011. Nine trees 9 years old were random selected for the study. Fifty-fourth the uniform branches (four branches per tree) of about the same length and diameter (2.5-3.0cm) from nine trees were selected for the experiment.

2.3.2.2. Data and methods collection

The canopy shape, diameter canopy, diameter trunk, plant height, number of branches level, leaf length, leaf width, spines density were recorded

The number of stamen, number of petal, flower initial stage, full blooming stage, petal fall stage. Percentage of fruit set, fruit maturity stage, theory yield/tree, Yield, average fruit weight, average flesh, fruit shape, fruit size, peel thickness, number of seed; number of mesocarp, percentage of peel, percentage of seed, percentage of endocarp, fruit length, fruit diameter were measurement

Fruit quality: TTS (oBrix), total sugar (mg/100g), % Citric acid (TA), and vitamin C (mg/100g) were measurement

Parameter of shoots growth:

The spring, summer, autumn and winter shoot initial as well as shoots growth was measurement

Number of node, leaf number per branche maturity at spring, summer, autumn and winter season were recorded, and the mean was calculated to compared

Shoot length maturity, and shoot diameter maturity at spring, summer, autumn and winter season were recorded

Study the relation between growth shoot (fruit- branch) and fruit yield in Dien grapefruit cultivar:

Branch length, branch diameter, number of leaf, and fruit yield were measurement likewise the methods was mentioned before

Study the relation between old of mother branch and fruit yield of Dien grapefruit:

Fifteen trees over 1 year old were random collected for the study. Sixty the uniform branches (four branches per tree) of about the same length and diameter (3.0cm) from fifteen trees were selected for the experiment

Study the relation between cross pollination and fruit yield, fruit quality:

Method research base on the methods of Japan include:

Data collection

- Non pollination; free-pollination; self-pollination; cross-pollination

Study the relation between C/N ratio on growth, yield and quality of grapefruit:

The leaf sample was collected random on thirty trees Dien grapefruit and was done one time per month at the orchard grapefruit. Twelve leaf/sample/tree was collected to measurement (four leaf/one and was done with three time). Leaf Carbon (C) content and leaf Nitrogen (N) content were measured by using UDK 142 (Velp-switzelend) follow the TCVN 4050 – 85 ISO

2.3.3. Study the effect of techniques on fruit yield and quality in Dien grapefruit at Thai Nguyen

Experiment 1: Study the effect of pruning on fruit yield and quality in Dien grapefruit cultivar

Experiment design: The experiment consists of three treatments including the control was design in Randomized Complete Block Design (RCBD) with three replicated and three trees was taken as an experiment unit.

Treatment 1: Pruning follows the structure of Fruit and vegetable research institute

Treatment 2: Pruning (open cutter) – cut on the top

Treatment 3: Control without pruning

Data collection and method research

Size of shoot at the different stage

Shoot length (cm), shoot diameter (cm)

flower initial stage, full blooming stage, petal fall stage

Fruit set (%)

Yield and component create yield

Experiment 2: Study effect of time girdling on yield and quality of Dien grapefruit cultivars

Experiment design: The experiment consists of five treatments including the control was design in Randomized Complete Block Design (RCBD) with three replicated and three trees was taken as an experiment unit. All branch leve 2 was chosen for the study to girdling

Treatment 1: Girdling at 15/11 every year

Treatment 2: Girdling at 30/11 every year

Treatment 3: Girdling at 15/12 every

Treatment 4: Girdling at 30/12 every year

Treatment 5: Control without girdling

Data collection and method research

flower initial stage, full blooming stage, petal fall stage

flower initial stage: 10% flower number/ tree was consider flower initial timing

full blooming stage: about 50% flower number/tree consider full blooming timing

petal fall stage: about 80% flower number/tree consider time of petal fall

Fruit set (%): fruit set was calculate at different stage

Yield and component create yield

Experiment 3: study the effect of girdling and rootstock on fruit yield of Dien grapefruit cultivar

Experiment design: The experiment consists of three treatments including the control was design in Randomized Complete Block Design (RCBD) with three replicated and three trees was taken as an experiment unit. All branch level 2 was chosen for the study to girdling

Treatment 1: Girdling at 15/11

Treatment 2: rootstock at 15/11

Treatment 3: control without girdling and rootstock

Data collection and method research like the experiment 2

Experiment 4: study the effect of GA₃ on fruit yield and quality in Dien grapefruit cultivar

Experiment design: The experiment consists of five treatments including the control was design in Randomized Complete Block Design (RCBD) with three replicated and three trees was taken as an experiment unit.

Treatment 1: control (spray water)

Treatment 2: spray GA₃ 30ppm

Treatment 3: spray GA₃ 40 ppm

Treatment 4: spray GA₃ 50ppm

Treatment 5: spray GA₃ 60ppm

Data collection: Fruit set (%) was recorded after spray at different application GA₃. Method research like the experiment 1

2.4. Statistical analysis

The data obtained from the study were analyzed using IRISTART statistical software and Microsoft Excel. The least significant difference was calculated following a significance F-test (at $P \leq 0.05$)

CHAPTER 3. RESULTS AND DISCUSSION

3.1. Investigate, assess the situation and identify the limited factor in the grapefruit production in Thai Nguyen province

3.1.1 *The situation of grapefruit production in Thai Nguyen province*

Table 3.1. The situation of grapefruit production in Thai Nguyen province in 2013

Order number	Regional	Area (ha)	Area of product (ha)	Yield ta/ha	Production (tons)
1	Thai Nguyen	9	79	120.76	954
2	Song Cong	38	36	115.28	415
3	Dinh Hoa	21	21	128.57	270
4	Vo Nhai	18	14	123.57	173
5	Phu Luong	9	9	131.11	118
6	Dong Hy	61	41	131.71	540
7	Dai Tu	62	60	137.00	822
8	Phu Binh	117	100	130.00	1300
9	Pho Yen	70	48	132.29	635
Total		475	408	-	5227

Source: Thai Nguyen department of Agriculture and Rural development in 2014)

In the table 3.1 showed that almost districts and towns of Thai Nguyen province are growing of grapefruits, in which Phu Binh district had largest area with 117ha, contrary is Phu Luong district had least area 9ha only. Besides, Dai Tu, Dong Hy and Thai Nguyen City also have an area from 60 to 80 hectares.

3.1.2. *Dien grapefruit production situation in Thai Nguyen province in 2013*

In fact shows that the area of grapefruit growers is rather large in Thai Nguyen province with 456ha. However, area grown grapefruit focused is not much, main grows is serving to the family, the area to grows above 0.5 ha per household not more. Data in table 3.2 show that area to dien grapefruit grows in Thai Nguyen province in 2013 was 262.6ha, the main concentration in Phu Binh and Dai Tu district with 67.2 and 40.8ha, respectively.

The average production of dien grapefruit has shown an upward trend, as may be observed in the table 3.3, concrete: the average

production in 2011 were 9 fruits/tree, in 2012 were 20 fruits /tree, and in 2013 with the highest yield were 48 fruits/tree.

Table 3.2. Dien grapefruit area on districts investigated in 2013

No	Regional	Area (ha)	Rate (%)
1	Dai Tu	40.8	15.5
2	Vo Nhai	11.7	4.5
3	Phu Luong	4.7	1.8
4	Dinh Hoa	9.3	3.5
5	Dong Hy	31.3	11.9
6	Thai Nguyen City	38.1	14.5
7	Song Cong Town	31.2	11.9
8	Phu Binh	67.2	25.6
9	Pho Yen	28.3	10.8
Total		262.6	100

(Source: Collected from the investigate data in 2013)

Table 3.3. The change in ‘Dien’ pomelo fruit yields/tree at the ages of 4 – 6 years in the period 2011 - 2012

Parameter	Year 2011	Year 2012	Year 2013
Average number of fruits/tree	9.37±1.57	20.10±2.79	47.97±2.83
Average fruit weight (g/fruit)	-	-	866.43±21.14

(Source: Data from the survey 2013 in the pomelo growers)

Table 3.4. Estimates of economic effectiveness of ‘Dien’ pomelo cultivation at the fruit-bearing stage in the surveyed growers

Unit: millionVND/ha

No	Item	Value
I	Total costs	12.906
1.1	Fertilize	12.321
1.2	Insecticide	0.585
1.3	Others	0
II	Total receipts	367.502
III	Average fruit sale price (1000 VND/fruit)	18.5
IV	Net profit	354.596

(Souce: Data from the survey 2013)

Annual investment costs for the mature orchards were estimated at near 13 million VND/ha (It does not include labor cost). With an average price of 18.500 VND per fruit, total revenue was estimated at

367.502 million VND per ha, resulting in net returns (net profit) of about 367.502 million VND/ha after deducting the fertilizer and pesticide costs.

3.2. Agro-biological characteristics of ‘Dien’ variety grown in Thai Nguyen

3.2.1. Morphological and growth characteristics of ‘Dien’ variety

3.2.1.1. Morphological characteristics of trunk and branch

Table 3.5. Some morphological characteristics of trunk and branch in ‘Dien’ variety

Parameter Tree	Branch angle	Spine density	Plant height (cm)	Stock diameter (cm)	Canopy diameter (cm)	Canopy shape	First branch number	First branch diameter (cm)	The height of first branch location (cm)	Secondary branch number
HN	-	-	458±23	21.43±13.0	441±15.0	-	2.64±0.43	-	21.55±4.58	7.43±0.8
HH	-	-	245±10	6.85±0.09	230±3.0	-	-	-	-	-
TN	narrow	absence	305.2±6.0	6.73±0.42	216.0±3.4	hemisphere	5.40±0.32	5.5±0.3	34.03±3.87	13.20±0.6
CV%	-	-	5.88	18.00	4.72	-	16.20	15.48	7.00	13.52

CV%: Calculated from the data collected in Thai Nguyen

Comparison of the trunk and branch characteristics of ‘Dien’ variety grown between in Thai Nguyen and Hiep Hoa district at the same age showed that there were no differences in diameter of tree stock and canopy, but plant height was dissimilar between these two cultivation areas. However, plant height was affected by many factors and among which, the pruning and cutting tree canopy may result in this difference. In comparison with cultivating conditions in Minh Khai, Ha Noi, pomelo ‘Dien’ variety at the same age of 11 years grown in Thai Nguyen had higher number of first and secondary branches.

3.2.1.2. Morphological characteristics of leaves

Table 3.6. Leaf morphology characteristics of pomelo ‘Dien’ variety

Loca.	Leaf length (cm)		Leaf width (cm)		Petiole length (cm)	Lamina length/width	length/width	Leaf margin	Lamina shape	Lamina color
	Largest lamina	Smallest lamina	Largest lamina	Smallest lamina						
HN	11.1±0.36	2.2±0.2	4.8±0.3	2.1±0.2	-	2.3±0.2	-	-	-	-
HH	12.0	-	8.5	-	-	-	-	-	elliptic	Dark green
TN	14.2±0.7	3.8±0.2	6.4±0.4	4.1±0.3	0.5±0.0	2.3±0.1	1.0±0.1	sinuate	ovate	Yellowish-green
CV%	15.06	17.87	18.53	23.03	24.93	19.23	18.21	-	-	-

All leaves of pomelo ‘Dien’ variety had an ovate shape, yellowish-green color and sinuate margin. The lamina length varied 12.3 - 17.8 cm and the average length was 3.8 cm whereas the lamina width presented 6.4 cm and the leaf width của eo lá ranged 3.0 – 5.9 cm. The average petiole length was 0.5 cm.

3.2.1.3. Morphological characteristics of fruits

The results of study on some fruit traits of grapefruit 'Dien' grown in Thai Nguyen are summarized in Table 3.7. It had a spheroid fruit shape, fruit length varied 10.7 – 14.4 cm, the average fruit diameter reached 11.3 cm. Fruits of 'Dien' grapefruit were assigned to small fruit size category, compared with some these of some other famous grapefruit varieties such as 'Nam Roi', 'Da Xanh' reaching an average fruit weight of 0.94 kg/fruit. Each grapefruit had 11 - 13 segments and pulp texture accounted for more than 50% of fruit weight. Each segment had 6 - 8 seeds, including large seeds, small seeds and aborted seeds.

Table 3.7. Evaluation of some fruit characteristics in the grapefruit 'Dien' variety

Parameter Tree	Fruit length (cm)	Fruit length (cm)	Fruit weight (kg)	Pulp texture weight (kg)	Number of segment	Number of large seeds	Number of small seeds	Number of aborted seeds
HT	11.85	12.45	0.80	0.48	12.60	65.6	-	-
HH	11.8	11.05	0.96	0.58	12.13	61	-	-
HN	12.5±0.4	15.3±0.3	0.94±0.16	0.60	12.6±0.3	69.8±3.1	-	-
TN	12.3±0.4	11.3±0.4	0.94±0.04	0.52±0.02	12.0±0.3	54.9±1.4	4.1±0.5	17.8±0.9
CV%	10.13	10.64	12.85	9.77	8.33	7.48	37.38	14.82

Some biochemical components in pulp texture of fruit grapefruit 'Dien' variety grown in Thai Nguyen are presented in Table 3.8.

Table 3.8. Biochemical components in pulp texture of fruit grapefruit 'Dien' variety

Tree	Percentage of dried pulp texture (%)	Total sugar content (%)	Fructose (%)	Total acid concentration (%)	Vitamin C(mg/100g)
HT	12.77	8.75	-	0.21	53.22
HN	12.73	9.2	-	0.11	52.16
TN	11.84±0.40	9.16±0.20	8.22±0.26	0.25±0.01	71.00±1.37
CV%	10.02	6.63	9.40	10.04	5.78

Comparison of some internal fruit quality parameters of grapefruit 'Dien' variety grown among three locations: Thai Nguyen, Ha Noi and Ha Tay found that while percentage of dried pulp texture and total sugar content did not much differ, total acid concentration and vitamin C had a great difference among these three growing locations. A quite low percentages (0.11%) of total acid concentration in fruits was found in grapefruits grown in Ha Noi while this parameter exhibited quite high values in Thai Nguyen and Ha Tay with 0.25% and 0.21%, respectively. The similar pattern was also shown in Vitamin C content, which obtained 71mg/100g pulp texture of fruits grown in Thai Nguyen compared with 52.16 mg/100g and 53.22mg/100g pulp texture of these grown in Ha Noi and Ha Tay,

respectively. These results indicated that grapefruit ‘Dien’ variety grown in its original conditions (Ha Noi) produced sweeter fruits than Thai Nguyen or Ha Tay.

3.2.2. The growth characteristics and relationship among shooting flushes

Spring flushes were formed with total number of 874 shoots/tree and 625 shoots of which (71.5%) became vegetative branches and the other 249 shoots became fruit-bearing branches (25.2%) and non-fruiting branches (3.3%). The data demonstrated that a few fruits would be produced in 2012 due to the fact that the numerous spring shoots turned into vegetative branches, which will produce fruit bearing shoots with many fruits.

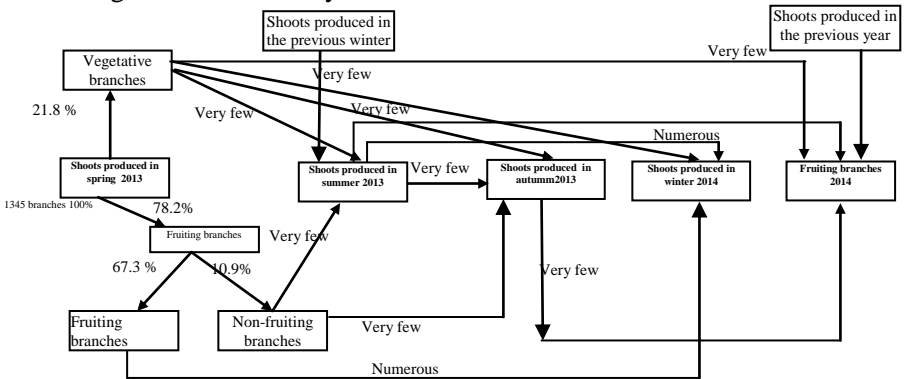


Figure 3.1. Formation and relationship among the shooting flushes in 2012 (few fruiting)

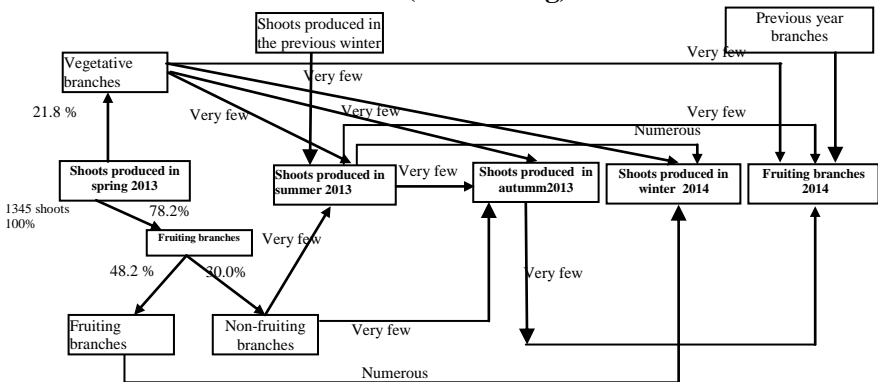


Figure 3.2. Formation and relationship among the shooting flushes in 2013 (numerous fruiting)

3.2.3. Research of correlation between stem, branch and yield of Dien grapefruit

Results analyzed the correlation between the growth targets of branch and yield are shown in Figure 3.3, 3.4, 3.5.

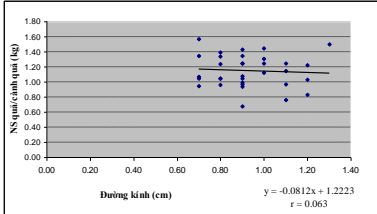


Figure 3.3. The correlation between branch's diameter and yield

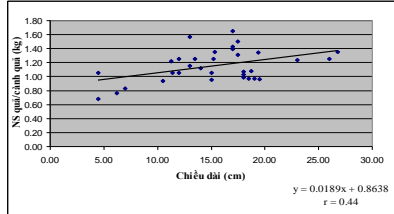


Figure 3.4. The correlation between branch's length and yield

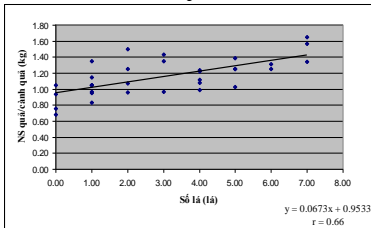
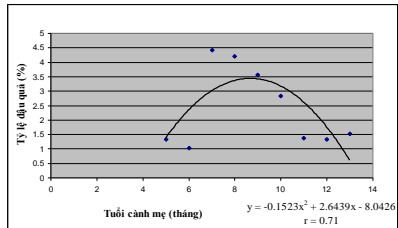


Figure 3.5. The correlation between number of leaves on branch and fruit yield



(Figure 3.6. The correlation between number of age of branch and fruit yield)

Results analyzed the linear correlation between branch's diameter and fruit yield, correlation coefficient $r = 0.063$ shown that the correlation is not significant.

Results analyzed the linear correlation between branch's length and fruit yield are shown in Figure 3.4, correlation coefficient $r = 0.44$ shown that linear correlation was not tight.

Correlation analysis between number of leaves on branch and fruit yield are shown in Figure 3.5. Linear correlation with a correlation coefficient $r = 0.66$ present the correlation is in inadequate level, the result shown that the number of leaves on branch and fruit yield correlated in the forward direction.

Correlation analysis between of age of branch and fruit yield shown that correlation $r = 0.71$ expressed the correlation was relatively tight.

3.2.4. Research of fertilization and pollination characteristics of Dien grapefruit

3.2.4.1. Research of effect of different pollen sources to fruiting rate

Research of effect of different pollen sources to fruiting rate of Dien grapefruit are presented in Figure 3.9. In the 2-year study (2011 and 2012), the percentage of fruiting on Dien grapefruit ranged from 0.00% to 22.53%. In which, self-receptor complexes (Formula 1: Dien x Dien) had the lowest fruiting rate, in 122 pollinated flowers (2011) and in 137 self-pollinated flowers (2012), only 1 flower became fruit (0.72%). On the other hand, the fruiting rate of pollinating formulas of different pollen sources in the 2 years study was quite high (7.58% - 22.53 %). In particular the combination of Dien x Phuc Trach was highest rate in both years of the study (19.6% and 22.53%). The pollinated formula of Dien grapefruit in two years reached the average level between selfpollination and cross pollination (9.60% and 7.58%).

Table 3.9. Effect of different pollen sources to the fruiting rate of Dien grapefruit

Formula	Pollinated Combination	2011			2012		
		Number of pollinated flowers (flowers)	Number of Fruited flower (fruit)	Percentage of Fruiting (%)	Number of pollinated flowers (flowers)	Number of Fruited flower (fruit)	Percentage of Fruiting (%)
1	Diễn x Diễn (a)	122	0	0.00	137	1	0.72
2	Open pollination (b)	222	21	9.60	145	11	7.58
3	Diễn x Da Xanh	79	12	15.18	112	20	17.85
4	Diễn x Năm Roi	57	8	14.03	46	6	13.04
5	Diễn x Phúc Trạch	51	10	19.60	71	16	22.53
6	Diễn x Cam Đường Canh	41	6	14.28	49	5	10.23

Notes: (a): pollination with same pollen sources (b) flowers in natural pollination

3.2.4.2. Research of pollination effect to fruiting rate, fruit weight and number of seed

The obtained data of research about effect of pollination and without pollination in two varieties of Dien grapefruit and Da Xanh grapefruit in two years 2011 and 2012 are shown in table 3.10.

As can be seen from obtained data, there are significant differences about fruiting rate between Dien Dien grapefruit and Da Xanh grapefruit. To Da Xanh grapefruit, the pollination and without

pollination did not affect to fruiting rate (varying from 4.2 to 5.2%). In contrast, Dien grapefruit had enormous fluctuations in the rate of fruiting between the perianth, reducing the male then perianth and natural pollination. Specifically if Dien grapefruit is reduced the male and done perianth, it is unable to fruit; in case of perianth, the fruiting rate is so low (0.8%); however in case of natural pollination, the fruiting rate is significant higher than Da Xanh grapefruit (9.6%).

Table 3.10 Effect of pollination and without pollination of fruit weight and seed number of Dien grapefruit in 2011

Race	Type of pollination	Total of experimental flowers	Number of Fruit and Fruiting rate (%)	Fruit weight (g)	Fruit weight (%)	Number of seed/ fruit		
						Completed Seed	Total number	
Dien grapefruit	perianth	250	2 (0.8)	224	23.2	0	5.5	5.5
	Perianth, reducing the male	87	0 (0)	-	-	-	-	-
	Natural pollination	222	21 (9.6)	966	100	75.6	3.6	79.2
Da Xanh grapefruit	Perianth	137	6 (4.4)	1202	94	0	2.5	2.5
	Perianth, reducing the male	119	5 (4.2)	1199	93.7	0	0	0
	Natural pollination	115	6 (5.2)	1279	100	97.7	4.3	102.0

(a) A day before the flowers bloom, perianth by dedicated pocket to avoid strange pollen contamination; A day before the flowers bloom, removing petals, anthers and perianth by dedicated pocket to avoid pollen contamination; (c) flowers are pollinated in natural conditions.

Similarly, the fruit weight of Dien grapefruit in perianth formula was just about 23.2% to compare with pollinated formula, while the fruit weight of Da Xanh grapefruit in perianth formula was 94% of natural pollination.

3.2.5. Research of the correlation between the C / N rate and Dien grapefruit yield

3.2.5.1. Evolution of C / N rate in months on Dien grapefruit

Results of volatility of C/N rate in months (8/2010 to 7/2011) were shown in Figure 3.17. C/N rate in 8,9,10 reached the lowest value in the year. Thereafter it rose sharply from October to February (above 1.1%). From the end of February, C/N rate began to decrease.

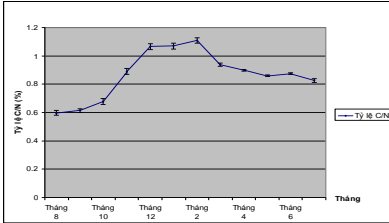


Figure 3.7. Evolution of C/N rate on Dien grapefruit from 8/2010 to 7/2011

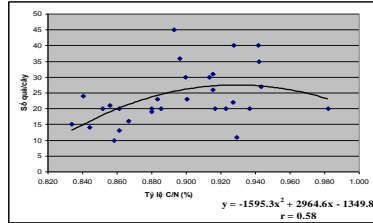


Figure 3.8. Correlation between the C/N rate and number of fruit on Dien grapefruit

3.2.5.2. Correlation between the C / N rate and number of fruit on Dien grapefruit

Correlation model between the C / N rate and number of fruit was estimated by the equation: $y = -1595.3x^2 + 2964.6x - 1349.8$ with the correlation coefficient $r = 0.58$. This means that the correlation between the rate of C/N and the number of fruits followed parabola graph parabola presented correlation over inadequate level.

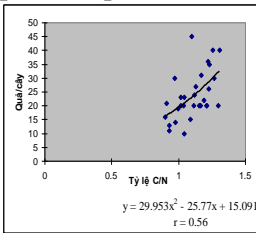


Figure 3.9. Correlation between the C/N rate and number of fruit at 12/2010

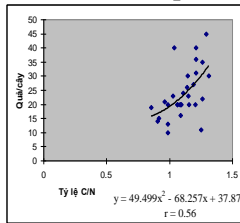


Figure 3.10. Correlation between the C/N rate and number of fruit at 1/2011

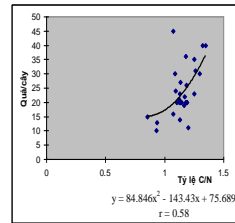


Figure 3.11. Correlation between the C/N rate and number of fruit at 2/2011

3.3 Research on the impact of farming techniques to the productivity, quality of Dien grapefruit variety in Thai Nguyen

3.3.1 The study on the effect of pruning method to the yield and the quality of the grapefruit in Thai Nguyen

The pruning method has positive effect on the rate of pollinating success, this also impacts the components of yield and final productivity of the grapefruit. The data of these effects demonstrates as in table 3.11

Table 3.11. The effects of pruning method to the quality and productivity of the grapefruit

Treatment	Number of fruit/tree	weight of fruit (kg/fruit)	Productivity (kg/tree)
T1: FAVRI Method	38.67	0.93	35.00
T2: Open pruning	39.67	0.94	37.29
T 3: Control	34.33	0.91	31.24
CV%	4.30	2.55	5.24
LSD.05	3.66	0.05	4.14

Table 3.11 demonstrates that pruning method enables trees to produce more fruits comparing to other methods at high feasibility of 95%. While control treatment only reached 34.33 of fruit per each tree, the open pruning method gained 39.67 of fruit per tree, the treatment of FAVRI Process showed at a level of 38.67 of fruit per tree. In contrast, the weight of fruit among different treatments showed no significant differences, and mostly reach from 0.91 to 0.94 kg per fruit. While the yield of control treatment reached 31.24 kg/tree, the treatment of open pruning method reached 37.29 kg/tree and treatment of FAVRI process achieving 35.96 kg / tree, are higher than control treatment with certainty at the 95% confidence level.

3.3.2. The effects at the time of girdling to productivity, quality of the Dien grapefruit growing in Thai Nguyen

Table 3.12. The effects at the time of girdling to the yield components, quality of the Dien grapefruit in Thai Nguyen in both year 2011 and 2012

Treatment	Number of fruit/tree	weight of fruit (kg/fruit)	Productivity (kg/tree)
Year 2011			
Control	34.33	0.91	31.45
Girdling date 15/11	39.67	0.93	36.96
Girdling date 30/11	40.67	0.94	38.21
Girdling date 15/12	38.33	0.90	34.39
Girdling date 30/12	36.67	0.91	33.37
CV%	5.14	2.66	5.82
LSD.05	3.67	0.05	3.82
Year 2012			
Control	34.67	0.91	32.70
Girdling date 15/11	41.67	0.92	37.67
Girdling date 30/11	42.00	0.92	39.05
Girdling date 15/12	39.67	0.91	34.77
Girdling date 30/12	39.00	0.90	34.50
CV%	6.57	4.95	5.55
LSD.05	4.87	0.09	3.74

The components of yield and yield of the Dien grapefruit in 2011 and 2012 are presented in Table 3.12

Table 3.12 shows that girdling date had a positive impact on the number of fruit on the tree. Specifically, three of the four girdling date in different times has had the number of fruit on tree is higher than the controlled trees at 95%, excepted treatment girdling in 30 May 12. In which the treatment on 15/11 and 30/11 have shown the highest number of fruit per tree, reaching 39.67 and 40.67 fruits/tree (for attaining 34.33 fruits/tree). Similarly, in 2012, two treatments on 15/11 and 30/11 also have number of fruit/tree higher than the control treatment with certainty achieved 41.67 and 42 fruits/tree (control gains 34.67 fruit/tree.)

While the number of fruit per tree is positively affected by girdling, the volume of fruit is not influenced by girdling. The weight of Dien grapefruit gains from 0.90 to 0.93 kg / fruit. The real yield of two treatments on 15/11 and 30/11 in both 2011 and 2012 was higher than the control treatment significantly.

3.3.3. The Effect of girdling to the productivity of the grapefruit in Thai Nguyen

Table 3.13. The effects of girdling, rootstock to the rate of C/N and productivity of grapefruit in 2011

Treatment	Sampling time				Yield	
	11/2011	12/2011	1/2012	2/2012	Number of fruit/tree	Productivity (kg/tree)
Girdling	0.31±0.01	0.37±0.01	0.60±0.03	0.59±0.03	36.53±0.07	33.61±0.72
Rootstock	0.34±0.01	0.36±0.01	0.53±0.01	0.58±0.04	33.75±0.71	31.05±0.65
Control	0.27±0.01	0.26±0.01	0.48±0.01	0.56±0.06	33.83±0.62	30.79±0.57
CV%	10.39	6.68	6.17	18.52	2.59	2.59
LSD.05	0.07	0.05	0.07	0.24	2.04	1.87

The table shows that the proportion of C/N in all three treatments increase continuously from January 11 to February (Table 3.13), in which, at each sampling time, the ratio of C/N between the treatments are almost different. At the time of November, the rate of C/N in girdling treatment gains 0.31% while the control treatment reached 0.27% and the rootstock reached the highest, 0.34%. The special thing of this stage, the rootstock treatment has ratio of C/N greater certainty than the remaining two treatments.

Girdling not only increases the C/N higher than other treatments significantly, but also impact positively on the performance / productivity and the number of fruit/plants. The table shows that, the number of fruit per each tree in the treatment of girdling was higher than the two other treatments at 95%, reaching 36.53 fruits/tree while control treatment and rootstock only reaches from 33.83 fruits/tree and 33.75 fruits/tree. Likewise, girdling achieves yield higher certainty than the remaining two treatments.

To study the correlation between the ratio of C/N with the number of fruit per tree in 2011 obtained the data in Figure 3.12. The correlation between the C/N with the number of fruits/tree in 2012 follows the model $y = 193.01x^2 - 154.83x + 64.28$ in which the correlation coefficient $r = 0.67$. Thus, in 2012 the correlation between the rate of C/N with the number of fruits/tree was tighter than in 2011, this may be due to the impact of a certain technical measures girdling and rootstock. To understand this issue, we conducted a correlation analysis between the technical methods to the number of fruit/tree of each treatment, data is presented in Figure 3.13, 3.14, 3.15

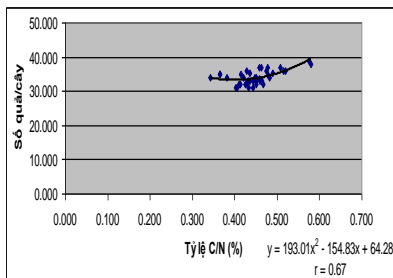


Figure 3.12 correlation between the ratio of C/N with the number of fruit per tree in 2011

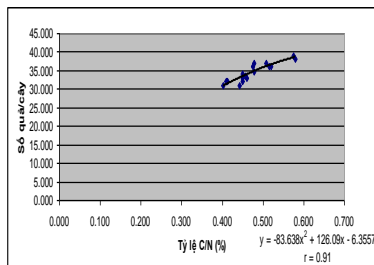


Figure 3.13 correlation between the ratio of C/N with the number of fruit per tree of girdling treatment

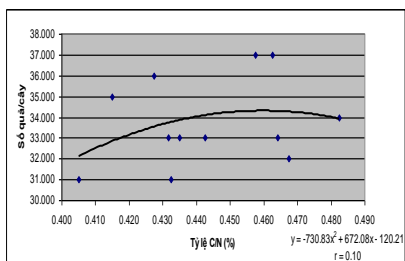


Figure 3.14 correlation between the ratio of C/N with the number of fruit per tree of rootstock treatment

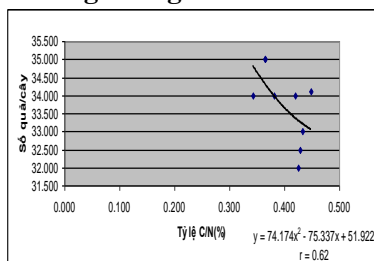


Figure 3.15 correlation between the ratio of C/N with the number of fruit per tree of control treatment

The correlation between the rate of C/N to the number of fruit per tree is shown in Figure 3.13, 3:14, 3:15. Due to the impact of girdling measures, so the ratio C/N was correlated quite closely to the number of fruits / tree demonstrated by model $y = -83.638x^2 + 126.09x - 6.3557$ while the correlation coefficient $r = 0.91$ (Figure 3:25). In contrast, rootstock measures increased ratio of C/N between the sampling times but did not correlate to the number of fruits/tree demonstrated by model $y = -730.83x^2 + 672.08x - 120.21$ with the correlation coefficient $r = 0.10$. Meanwhile, with the control (non-impact), the correlation between the ratio of C/N to the number of fruits/tree at average level, reflected in the model $y = 74.174x^2 - 75.337x + 51.922$ with a correlation coefficient $r = 0.62$.

3.3.4. Study the effect of GA₃ on fruit yield and quality in Dien grapefruit cultivar

Table 3.14. effects of spraying GA₃ to the pollinating success of Dien grapefruit in Thai Nguyen

Unit: %

Treatment	GA ₃ (ppm)	Spraying time			1 st fruit dropping
		Before blooming 10 days	Blooming	After blooming 10 days	
1	Control (spraying water)	3.5	3.25	2.3	2.7
2	30 ppm	3.9	4.9	4.3	5.5
3	40 ppm	4.1	4.8	4.7	6.1
4	50 ppm	4.7	5.1	5.9	7.2
5	60 ppm	3.8	4.1	5.2	4.7

(spraying each time separately: each spraying was conducted on different trees, spraying the whole tree, Each treatment sprays 3 trees, 1 tree is 1 repeating)

The data shows that the sprayed GA₃ separately is fruiting at higher proportion than the control treatment at all times. The ratio of different spraying and at different times of spraying are also making different fruiting rate. Firstly, in all spray treatments, the treatment 4 with ratios of 50 ppm GA₃ has the highest proportion of fruiting, ranged from 4.7 to 7.2%, while the control treatment has 2.7 to 3.5%. Secondly, in all the time of spraying, the spraying GA₃ on stage of physiological fruit drop has highest fruiting rate, varying from 4.7% (treatment 5) to 7.2% (treatment 4). Thus the appropriate concentration of GA₃ in experiment is 50 ppm spraying at the first time of physiological fruit drop.

When spraying repeatedly in different stages and different levels of GA₃ data obtained table 3.15. Spraying GA₃ at the time of before blooming 10 days, the fruiting rate vary from 3.8 to 5.1%, control treatment gained 3.5%. If spraying 2 times at 10 days before the flowers bloom and the flowers intensive blooming, the fruiting rate fluctuates between 3.5 and 4.8%, control treatment gains 2.6%.

Table 3.15. The effect of number spraying GA₃ to the fruiting rage when repeating spraying

Đơn vị: %

Treatment	GA ₃ (ppm)	spraying 1 time before blooming 10 days (A)	Spraying before blooming 10 days+ when flower intensive blooming (B)	Spraying before blooming 10 days+ when flower intensive blooming + after blooming 10 days (C)	Spraying before blooming 10 days+ when flower intensive blooming + first time physiological fruit drop (D)
1	Control (spraying water)	3.5	2.6	1.5	1.2
2	30 ppm	3.9	3.5	2.9	2.5
3	40 ppm	4.1	3.9	3.5	3.1
4	50 ppm	5.1	4.8	4.6	4.1
5	60 ppm	3.8	3.5	3.2	2.8

To spray three times in the period before the flowers bloom 10 days, when flowers bloom intensively and after flowering 10 days, the proportion of fruiting rate in the highest treatment (treatment 4: 50 ppm) 3 times higher than control treatment, 4.6% and 1.5% respectively . Similarly, if spraying again on the stage of physiological fruit drop, the rate of fruiting of treatment 4 (50ppm) is 4 times higher than the control treatment. Thus, in conditions permitting, can apply four sprays in the period 10 days before the flowers bloom, the flowers intensive bloomed, after flowering 10 days and in the first time of physiological fruit drop in concentrations of 50 ppm will have highest fruiting rate, higher than the control (spraying water) to almost 4 times.

Productivity is the determinant of any technical measures. Studying the effects of spraying GA₃ to the components of yield and yield obtained date in table 3.16.

Table 3.16. The effect of spraying GA₃ to productivity of Dien grapefruit

Treatment	GA ₃ (ppm)	Number of fruit (fruit/tree)	Weight of fruit (kg)	productivity/tree (kg)
1	Control (Spraying water)	32.7	0.87	28.4
2	30 ppm	43.3	0.92	39.8
3	40 ppm	49.3	0.93	45.8
4	50 ppm	57.0	0.98	55.7
5	60 ppm	45.0	0.99	44.6

Table 3.16 is presented that spraying GA₃ had a very positive impact on the number of fruits/tree, the volume and the yield of fruit . The number of fruits/tree varied from 32.7 fruits/tree (control treatment) to 57 fruits/tree (Treatment 4). Volume of fruits fluctuates from 0.87kg/fruit (control treatment) to 0.99kg/fruit (treatment 5). Spraying GA₃ made the difference in yield between the experimental treatments. At concentrations of 50ppm (Treatment 4) gains the highest yield, 55.7 kg / tree, while the control treatment gains only 28.4 kg/tree.

CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

1. In 2013, Thai Nguyen province has 475 ha of grapefruit, in which the area of Dien grapefruit is 262.6 ha. Limiting factors: Small-scale production; farmers not applying technology process; great development potential of Dien grapefruit but they still not be fully exploited.

2. Agro-biological characteristics of Dien grapefruit

- Dien grapefruit plants are vertical and thornless. The canopy structure is hemispherical. The blade is 14.2 cm in length and 6.4 cm in width. Fruits are globular with 10.7 cm to 14.4 cm long, 11.3 cm in the average fruit diameter, and 0.94 g in the average weight.

- The relationship between the length, leaf number of effective branches and fruit yield is moderate with $r= 0.44$ and 0.66 , respectively. The relationship between the age of effective braches and fruit yield is closer with $r= 0.71$.

- In case of self-pollination, the fruiting rate of Dien grapefruit is low while the Dien x Phuc Trach combination had the highest fruiting rate and fruit yield.

3. The relationship between C/N ratio and fruit number/plant is moderate ($r= 0.58$). Due to the effects of girdling, the relationship between C/N ratio and fruit number/plant is quite close with the equation $y = -83.638x^2 + 126.09x - 6.3557$, in which $r=0.91$.

4. Pruning induced the flourishing flowering time earlier 7- 10 days, pruning also affected on the fruiting rate and fruit number/plant of Dien grapefruit.

5. Girdling induced the flowering time of Dien grapefruit earlier, the fruiting rate and fruit number/plant higher in the treatments which were girdled on 15 November and 30 November.

6. Using GA_3 with 4 times: 10 days prior to flowering, in the flourishing flowering time, 10 days after the flourishing flowering time, and 10 days after the first physiological fruit drop at 50 ppm concentration induced the highest fruiting rate, it is four times higher than that in the control treatment (using water)

2. Recommendations

Dien grapefruit growers in Thai Nguyen province should apply some technical measures such as girdling to control the flowering time of grapefruit in November every year; Additional pollination or additional planting with other grapefruit varieties in the garden; Using GA_3 at 50ppm concentration at the times: Prior to flowering, at the flourishing flowering time, after the flourishing flowering time, and the first physiological fruit drop.