A TRIAL OF *NEOLAMARCKIA CADAMBA* IN THANH HOA PROVINCE

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Abstract: *A trial of Neolamarckia cadamba in Thanh Hoa province has the following results: Neolamarckia cadamba is the easy growing and photophillic tree, highly adaptable to natural conditions of Thuong Xuan, Nhu Thanh, and Tinh Gia which are representatives of the mountainous area, midland area and delta coastal area, respectively, in Thanh Hoa province. The tree grows fast in the months with the average rainfall ranging from 178.6 to 437.8mm, with the average temperature from 24 to 30°C, and with the mean humidity from 65.9 to 87.9%. Neolamarckia cadamba grows well in deep, moist arable layers, with pH ranging from acidity to slight alkalinity, with a high total organic matter and high dissolved organic nitrogen content. The capable areas of Neolamarckia cadamba growing and developing in Thanh Hoa province include 45 communes of 9 districts.*

Keywords: *Neolamarckia Cadamba, capable areas, Thuong Xuan, Nhu Thanh, Tinh Gia.*

1. Introduction

Neolamarckia cadamba is the woody, straight and evergreen tree. It can reach up to 35m in height and over 100cm in diameter [5]. It has a high utilization rate of timber. The timber has lightly yellow colour with a fine texture, straight grains. The timber air dries rapidly without cracking and being termited. The timber is used to produce household items, handicrafts, trunks, architectural decorations, etc. It is also a very good material for making artificial fiberboards, medium density fiberboard and pulp, etc. *Neolamarckia cadamba*'s bark and roots can be used to produce medicines. Its leaves can be used as animal food [5]. Especially, the trees are valuable in protecting soil, regenerating forests and windbreaking in agroforestry systems [4].

So far, there has not been any research in generating and planting *Neolamarckia cadamba* in Thanh Hoa province. Therefore, the implementation of the study "A trial of *Neolamarckia cadamba* in Thanh Hoa province" is necessary.

2. Methodology

2.1. Study areas and time

The representative of the ecological regions in Thanh Hoa province chosen for the study included: Thuong Xuan district (a representive of the mountainous area), Nhu Thanh district (a representive of the midland area), and Tinh Gia district (a representive of delta coastal area).

The study was implemented from June 2016 to the end of December 2018.

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2.2. Study contents

The study includes the following contents: (1) Selecting sites for the trial models of *Neolamarckia cadamba*; (2) Carrying out the trial, (3) Identifying suitable sites to grow *Neolamarckia cadamba* in Thanh Hoa province.

2.3. Study methods

The research methods used in the study included inheritance methods, expert methods, analysis methods and mapping methods [1], [2], [3]. The 1st content was carried out by the methods: Determining the slope of planting soil with a DQY-1 compass [1]; Determining the vegetative state by the actual observation methods [1]; Determining soil factors by soil profile excavation methods (in each district, three areas were excavated for soil analysis). The criteria of soil profile included soil thickness, organic matter content (OM), pH, dissolved organic nitrogen content (N_{dt}), and content of easily digestive phosphorus P_2O_5 (Number of samples: 3 samples/ point x 3 points = 9 samples).

The 2nd content was implemented by planting, tending and indicators monitoring in Tinh Gia district, Nhu Xuan district and Thuong Xuan district. *Neolamarckia cadamba* models were arranged in three sites (0.5 ha/site) as follows: Xuan Loc commune of Thuong Xuan district: 1.5 ha; 1, 2, 3 lots; 2 plot and 530 sub-area; Phuong Nghi commune of Nhu Thanh district: 1,5 ha; 1, 2, 3 lot; 5A plot and 572 sub-area; Truong Lam commune of Tinh Gia district: 1.5 ha; 1, 2, 3 lots; 3 plot; 37 sub-area. The trees were planted under a monoculture method with a planting density of 1,100 trees/ ha, a 3.0m distance from tree to tree; 3.0m distance from row to row and planted by pot seedlings [5]. Every month, growth data including survival rate, diameter of stump, twig growing height, and diameter of crown were noted and collected. The 3rd content were carried out by collecting, processing, synthesizing and analysing data to determine suitable sites for planting *Neolamarckia cadamba*; establishing commune and district maps for planting and developing areas in Thanh Hoa province (Digital map of commune 1/10,000 scale: 45 communes, digital maps of district 1/50,000 scale: 09 districts).

3. Results and discussion

3.1. Trial site selection for Neolamarckia cadamba

3.1.1. Site types, soil sampling and soil sample analysis

Representative of the mountainous area

Xuan Loc commune of Thuong Xuan district was selected as a representative of the mountainous area. The slope of planting soil, soil profile, and vegetative state of three sites were determined and summarized in Table 1.

Table 1. *The slope of planting soil, soil profile, and vegetative state of three sites in Xuan Loc commune of Thuong Xuan district*

Content	1st site	2nd site	3rd site
Soil type	Grayish brown feralite soil	Grayish brown feralite soil	Grayish brown feralite soil
Soil thickness (cm)	>80	>80	>80
Soil mechanical composition	Medium clay	Medium clay	Medium clay
Mixed stones percentage (%)	15 - 20	15 - 23	15 - 20

Floating rocks percentage (%)	5	6	4
Average slope (degree)	10 - 15	10 - 15	15 - 25
pH	5,67 (slightly acidic)	5,09 (slightly acidic)	5,86 (slightly acidic)
OM (%)	1,564 (poor)	2,302 (poor)	1,383 (poor)
Digestible P_2O_5 (mg/100g)	2,31 (neutral)	2.38 (neutral)	3,92 (neutral)
Dissolved organic nitrogen Ndt (mg/100g)	4,2 (very poor)	6,44 (very poor)	1,95 (very poor)
Vegetative state	IA (*Lophatherum gracile Brongn*, *Phragmites australis*, *Chromolaena odorata*, with 0.5÷ 1.5m average height, normal growth and 20÷ 30% coverage	IB (*Lophatherum gracile Brongn, Saccharum spontaneum, Phragmites australis, Chromolaena odorata, Holarrhena pubescens, Cratoxylum maingayi* with 1.5÷ 2.5m average height, normal growth and 25÷ 40% coverage)	IB (*Lophatherum gracile Brongn, Coix lacryma-jobi*, *Chromolaena odorata,* with 1.5÷ 2.5m average height, normal growth and 25÷ 45% coverage)

Representative of the midland area

Phuong Nghi commune of Nhu Thanh district was selected as a representative of the midland area. The slope of planting soil, soil profile, and vegetative state of three sites were determined and summarized in table 2.

Table 2. *The slope of planting soil, soil profile, and vegetative state of three sites in Phuong Nghi commune of Nhu Thanh district*

Content	1st site	2nd site	3rd site
Soil type	Light yellow feralite soil	Light yellow feralite soil	Light yellow feralite soil
Soil Thickness (cm)	>100	>100	>100
Soil mechanical composition	Medium clay	Medium clay	Medium clay
Mixed stones percentage (%)	8 - 12	4 - 5	4 - 5
Floating rocks percentage (%)	5 - 7	3	3
Average slope (degree)	10 - 15	10 - 15	20 - 25
pH	4,60 (acidic)	4,60 (acidic)	4,84 (acidic)
OM (%)	1,564 (poor)	1,841 (poor)	1,241 (poor)
Digestible P_2O_5 (mg/100g)	5,66 (neutral)	4,09 (neutral)	7,99 (neutral)
Dissolved organic nitrogen Ndt (mg/100g)	4,38 (very poor)	5,88 (very poor)	3,64 (very poor)
Vegetative state	IA (*Lophatherum gracile Brongn, Imperata*	IB (*Lophatherum gracile Brongn*, *Phragmites*	IB (*Lophatherum gracile Brongn*, *Phragmites*

	cylindrica (L.) Beauv, *Phragmites australis*, with 1.0÷ 2.5m average height, normal growth and 25÷ 30% coverage)	*australis*, *Coix lacryma-jobi, Chromolaena odorata, Schizostachyum* sp, with 2.5÷ 3.0m average height, good growth and 30÷ 45% coverage)	*australis*, *Coix lacryma-jobi, Chromolaena odorata, Schizostachyum* sp, with 2.5÷ 3.0m average height, good growth and 30÷ 50% coverage.)

Representative of the delta coastal region

Truong Lam commune of Tinh Gia district was selected as a representative of the delta coastal area. The slope of planting soil, soil profile, and vegetative state of three sites were determined and summarized in table 3.

Table 3. *The slope of planting soil, soil profile, and vegetative state of three sites in Truong Lam commune of Tinh Gia district*

Content	**1st site**	**2nd site**	**3rd site**
Soil type	Reddish yellow feralite soil	Reddish yellow feralite soil	Reddish yellow feralite soil
Soil thickness (cm)	>50	>50	>50
Soil mechanical composition	Low to medium clay	Low to medium clay	Low to medium clay
Mixed stones percentage (%)	8 - 10	25 - 35	20 - 30
Floating rocks percentage (%)	5 - 7	10 - 12	10 - 13
Average slope (degree)	11 - 15	10 - 15	15 - 20
pH	6.99 (neutral)	7.35 (neutral)	6.46 (neutral)
OM (%)	1.288 (poor)	1.610 (poor)	1.288 (poor)
Digestible P_2O_5 (mg/100g)	2.84 (very poor)	2.48 (very poor)	2.85 (very poor)
Dissolved organic nitrogen Ndt (mg/100g)	4.2 (neutral)	6.16 (neutral)	4.2 (neutral)
Vegetative state	IA (*Lophatherum gracile Brongn, Saccharum spontaneum, Phragmites australis, Chromolaena odorata, Holarrhena pubescens, Cratoxylum maingayi* with 0.5÷ 1.4m average height, normal growth and 25÷ 40% coverage)	IB (*Lophatherum gracile Brongn, Saccharum spontaneum, Chromolaena odorata,* with 0.5÷ 1.5m average height, normal growth and 20÷ 30% coverage)	IB (*Lophatherum gracile Brongn, Saccharum spontaneum, Phragmites australis, Chromolaena odorata, Holarrhena pubescens, Cratoxylum maingayi* with 1.5÷ 2.5m average height, normal growth and 25÷ 40% coverage)

3.1.2. Meteorological results

In the areas where *Neolamarckia cadamba* have been planted, the mean yearly temperature of 2013, 2014, and 2015 ranged from 16.7°C to 30°C. The highest mean temperature was in June and the lowest one was in January. The mean monthly temperature was from 24.0°C to 24.4°C. These temperature ranges were ecologically suitable for the growth and development of *Neolamarckia cadamba* [5].

In 2013, 2014 and 2015, the mean air humidity in Thuong Xuan, Tinh Gia and Nhu Thanh districts were 85.3%, 84.2%, and 84.3%, respectively. The highest mean humidity was in March with 92.2% (in Tinh Gia) and the lowest one was in June with 65.9%.

The mean rainfall in Nhu Thanh, Tinh Gia, and Thuong Xuan districts was 1.696 mm, 1.883 mm, and 1.836 mm, respectively. In Nhu Xuan, the highest mean rainfall was in September (387.3 mm), the lowest one was in January (13.3 mm). In Tinh Gia, the highest mean rainfall was in September (437.8 mm) and the lowest one was in January (12.2 mm). In Thuong Xuan, the highest mean rainfall was in July (336.7 mm) and the lowest one was in January (27.4 mm). Therefore, in Nhu Xuan and Thuong Xuan, the rains were mainly from May to November, while in Tinh Gia, they were mainly from June to November.

3.2. Trial results of planting Neolamarckia cadamba

3.2.1. Survival rates of Neolamarckia cadamba at the sites

The survival rates of *Neolamarckia cadamba* after one month of planting in the sites of three districts are shown in Table 4.

The survival rates of *Neolamarckia cadamba* at all sites were high. The highest rate was in 2nd site in Thuong Xuan with 95% and the lowest one was in 3rd site of Thuong Xuan and Tinh Gia with 80%.

The survival rates of *Neolamarckia cadamba* after 24 months of planting at all sites were high with over 90% (Table 1). The results show that *Neolamarckia cadamba* has a high survival rate if they are planted by standard seedlings with right tending, planted on the cool days and planted in high humidity soil.

Table 4. *Survival rate of Neolamarckia cadamba after one month and after 24 months of planting (%)*

District	After one month of planting			After 24 months of planting		
	1st site	2nd site	3rd site	1st site	2nd site	3rd site
Tinh Gia	85.0	91.0	80.0	91.0	94.0	89.0
Nhu Thanh	85.0	90.0	83.0	95.0	97.0	93.0
Thuong Xuan	90.0	95.0	80.0	92.0	94.0	90.0

3.2.2. Monthly growth of Neolamarckia cadamba

In mountainous area

In Thuong Xuan district, measuring the growth of *Neolamarckia cadamba* after 24 months shows that the mean diameter of stump, the mean twig growing height, and the mean diameter of crown was 7.62cm, 3.22 m, and 3.06m, respectively at the 1st site; was 8.78cm, 3.25m, and 2.88m at the 2nd site; and was 6.92cm, 2.99m, and 2.64m at the 3rd site (Table 5).

Table 5. *Monthly growth of Neolamarckia cadamba in Thuong Xuan*

Month	Growth indicators								
	1st site			2nd site			3rd site		
	D_s (cm)	H_t (m)	Dc (m)	D_s (cm)	H_t (m)	Dc (m)	D_s (cm)	H_t (m)	Dc (m)
10/2016	0.51	0.45	0.25	0.60	0.47	0.26	0.49	0.45	0.22
11/2016	0.53	0.45	0.25	0.62	0.47	0.26	0.50	0.45	0.22
12/2016	0.54	0.45	0.25	0.62	0.47	0.26	0.51	0.45	0.22
1/2017	0.55	0.45	0.25	0.63	0.47	0.26	0.52	0.45	0.22
2/2017	0.59	0.47	0.27	0.70	0.49	0.28	0.56	0.47	0.24
3/2017	0.71	0.53	0.32	0.8	0.54	0.32	0.67	0.51	0.28
4/2017	0.82	0.57	0.36	0.96	0.58	0.36	0.77	0.55	0.31
5/2017	1.11	0.68	0.47	1.30	0.69	0.47	1.02	0.65	0.41
6/2017	1.45	0.82	0.63	1.66	0.83	0.58	1.31	0.76	0.52
7/2017	2.03	1.04	0.85	2.37	1.06	0.81	1.87	0.99	0.73
8/2017	2.47	1.21	1.02	2.88	1.23	0.98	2.27	1.15	0.88
9/2017	3.09	1.43	1.26	3.58	1.45	1.20	2.82	1.35	1.09
1/2018	3.84	1.75	1.57	4.45	1.77	1.48	3.51	1.64	1.35
2/2018	4.02	1.81	1.63	4.65	1.84	1.55	3.67	1.70	1.41
3/2018	4.34	1.94	1.76	5.02	1.96	1.67	3.95	1.82	1.52
4/2018	4.69	2.07	1.90	5.42	2.10	1.80	4.27	1.94	1.64
5/2018	5.17	2.26	2.09	5.97	2.29	1.97	4.70	2.11	1.80
6/2018	5.74	2.48	2.32	6.62	2.51	2.19	5.22	2.32	2.00
7/2018	6.34	2.72	2.56	7.32	2.75	2.41	5.77	2.54	2.21
8/2018	6.98	2.97	2.81	8.05	3.00	2.65	6.34	2.76	2.43
9/2018	7.62	3.22	3.06	8.78	3.25	2.88	6.92	2.99	2.64

Note: D_s: Diameter of stump , H_t: twig growing height, Dc : Diameter of crown

However, the mean diameter of tree trunks in Thuong Xuan increased unevenly by month (Figure 1). The mean diameter of *Neolamarckia cadamba*'s trunks increased slowly in the period from the end of October to the end of May (Figure 1). On the other hand, it increased significantly in the period from early June to the end of September (Figure 1). The climatic factors of the years shows that the mean rainfall from October of the last year to May of the following year was low, and the one from June to the end of September was high. All these results indicates that *Neolamarckia cadamba* grew quickly in the rainy season.

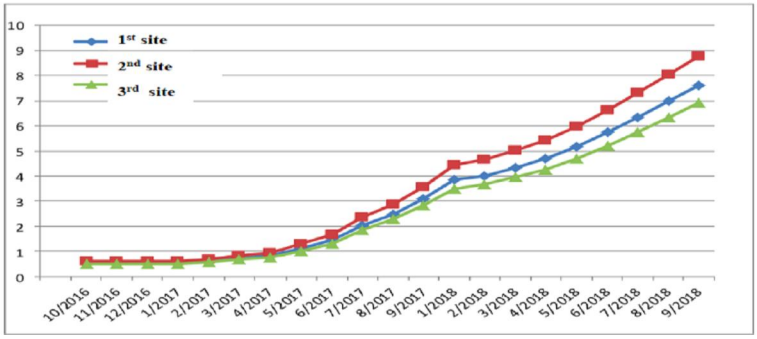


Figure 1. *The mean diameter of tree trunks in Thuong Xuan*

At 2nd site, *Neolamarckia cadamba* grew best, followed by those at 1st site, and 3rd site, respectively. Matching this to the characteristics of soil at the sites shows that trees planted on the site with high content of organic matter (OM) and high dissolved organic nitrogen (Ndt) grew best.

In Nhu Thanh district, measuring the growth of *Neolamarckia cadamba* after 24 months shows that the mean diameter of stump, the mean twig growing height, and the mean diameter of crown was 11.75cm, 4.84m, and 3.53m, respectively at the 1st site; was 13.76cm, 5.29m, and 3.89m at the 2nd site; and was 11.09cm, 4.62m, and 3.33m at the 3rd site (Table 6).

Table 6. *Monthly growth of Neolamarckia cadamba in Nhu Thanh*

Month	Growth indicators								
	1st site			2nd site			3rd site		
	D_s (cm)	H_t (m)	Dc (m)	D_s (cm)	H_t (m)	Dc (m)	D_s (cm)	H_t (m)	Dc (m)
10/2016	0.52	0.45	0.25	0.58	0.49	0.26	0.50	0.44	0.22
11/2016	0.57	0.47	0.26	0.63	0.51	0.28	0.52	0.46	0.24
12/2016	0.58	0.47	0.26	0.66	0.51	0.28	0.54	0.46	0.24
1/2017	0.59	0.47	0.26	0.68	0.51	0.28	0.56	0.46	0.24
2/2017	0.62	0.49	0.27	0.73	0.52	0.29	0.58	0.47	0.25
3/2017	0.80	0.56	0.32	0.94	0.60	0.35	0.72	0.53	0.29
4/2017	1.09	0.67	0.41	1.27	0.72	0.44	0.99	0.64	0.37
5/2017	1.51	0.83	0.53	1.74	0.90	0.58	1.38	0.79	0.48
6/2017	2.08	1.06	0.70	2.40	1.15	0.76	1.92	1.00	0.64
7/2017	3.01	1.42	0.97	3.47	1.55	1.06	2.81	1.35	0.90
8/2017	4.37	1.95	1.37	5.03	2.13	1.50	4.09	1.86	1.27
9/2017	5.40	2.36	1.67	6.22	2.57	1.84	5.08	2.25	1.57
10/2017	6.24	2.68	1.91	7.18	2.93	2.10	5.87	2.56	1.80
11/2017	6.26	2.69	1.92	7.21	2.94	2.11	5.90	2.57	1.81
12/2017	6.29	2.70	1.93	7.24	2.95	2.12	592	2.58	1.81
1/2018	6.31	2.71	1.94	7.27	2.96	2.13	5.95	2.59	1.82
2/2018	6.52	2.80	2.00	7.51	3.05	2.20	6.14	2.67	1.88
3/2018	6.83	2.92	2.09	7.86	3.18	2.30	6.44	2.79	1.97
4/2018	7.22	3.07	2.20	8.31	3.35	2.42	6.81	2.93	2.07
5/2018	7.80	3.29	2.37	8.97	3.60	2.61	7.35	3.14	2.23
6/2018	8.52	3.58	2.58	9.80	3.91	2.84	8.04	3.42	2.43
7/2018	9.51	3.97	2.87	10.94	4.33	3.16	8.98	3.78	2.71
8/2018	10.76	4.45	3.24	12.37	4.86	3.57	10.16	4.25	3.06
9/2018	11.75	4.84	3.53	13.60	5.29	3.89	11.09	4.62	3.33

However, the mean diameter of tree trunks in Nhu Thanh increases unevenly by month (Figure 2). The mean diameter of *Neolamarckia cadamba*'s trunks increased slowly in the period from the end of October to the end of May (Figure 2). On the other hand, it increased significantly in the period from early June to the end of September (Figure 2). The climatic factors of the years shows that the mean rainfall from October of the last year to May of the following year was low, and the one from June to the end of September was high. All these results indicates that *Neolamarckia cadamba* grow quickly in the rainy season.

At 2nd site, *Neolamarckia cadamba* grew best, followed by those at 1st site, and 3rd site, respectively. Matching this to the characteristics of soil at the sites shows that trees planted on the site with high content of OM and high easily digestible (Ndt) grew best.

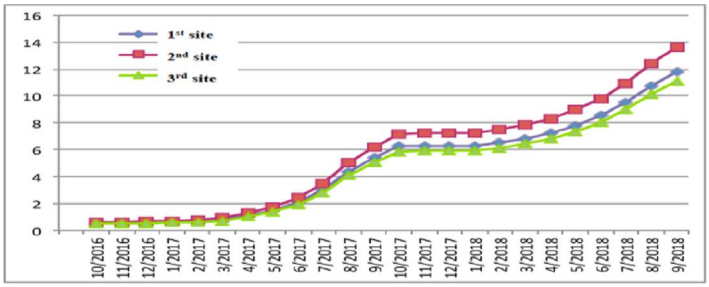


Figure 2. *The mean diameter of tree trunks in Thuong Xuan*

In the delta coastal region

In Tinh Gia district, measuring the growth of *Neolamarckia cadamba* after 24 months shows that the mean diameter of stump, the mean twig growing height, and the mean diameter of crown was 7.24cm, 3.84m, and 2.95m, respectively at the 1st site; was 7.38cm, 4.16m, and 3.49m at the 2nd site; and was 5.87cm, 2.70m, and 2.56m at the 3rd site (Table 7).

Table 7. *Monthly growth of Neolamarckia cadamba in Tinh Gia*

Month	Growth indicators								
	1st site			2nd site			3rd site		
	D_s (cm)	H_t (m)	Dc (m)	D_s (cm)	H_t (m)	Dc (m)	D_s (cm)	H_t (m)	Dc (m)
10/2016	0.54	0.47	0.25	0.58	0.49	0.28	0.48	0.45	0.22
11/2016	0.55	0.47	0.25	0.60	0.49	0.28	0.49	0.45	0,.22
12/2016	0.56	0.47	0.25	0.61	0.49	0.28	0.50	0.45	0.22
1/2017	0.57	0.47	0.25	0.62	0.49	0.28	0.51	0.45	0.22
2/2017	0.61	0.49	0.27	0.66	0.52	0.30	0.53	0.46	0.24
3/2017	0.73	0.55	0.32	0.77	0.58	0.36	0.63	0.51	0.28
4/2017	0.85	0.61	0.36	0.88	0.64	0.41	0.74	0.54	0.32
5/2017	1.14	0.76	0.48	1.18	0.80	0.55	0.90	0.60	0.42
6/2017	1.47	0.92	0.61	1.51	0.98	0.70	1.16	0.72	0.54
7/2017	1.98	1.18	0.82	2.03	1.26	0.95	1.57	0.89	0.72
8/2017	2.60	1.39	0.99	2.65	1.49	1.15	2.02	1.03	0.86
9/2017	3.27	1.83	1.34	3.34	1.97	1.57	2.60	1.33	1.17
10/2017	3.52	1.96	1.44	3.59	2.11	1.69	2.80	1.42	1.26
11/2017	3.55	1.97	1.45	3.62	2.12	1.71	2.82	1.43	1.27
12/2017	3.63	2.02	1.49	3.71	2.17	1.75	2.89	1.46	1.30
1/2018	3.69	2.04	1.51	3.77	2.20	1.77	2.94	1.48	1.32
2/2018	3.85	2.13	1.58	3.93	2.29	1.85	3.07	1.53	1.37
3/2018	4.15	2.28	1.70	4.24	2.46	2.00	3.31	1.64	1.48
4/2018	4.48	2.45	1.83	4.57	2.64	2.16	3.57	1.75	1.59
5/2018	4.93	2.67	2.02	5.03	2.89	2.38	3,93	1.90	1.75
6/2018	5.47	2.95	2.23	5.58	3.18	2.64	4.36	2.09	1.94
7/2018	6.04	3.24	2.46	6.16	3.50	2.91	4.82	2.28	2.14
8/2018	6.64	3.54	2.71	6.77	3.83	3,20	5.30	2.49	2.35
9/2018	7.24	3.84	2.95	7.38	4.16	3.49	5.78	2.70	2.56

However, the mean diameter of tree trunks in Tinh Gia increases unevenly by month (Figure 3). The mean diameter of *Neolamarckia cadamba*'s trunks increased slowly in the period from the end of October to the end of May (Figure 3). On the other hand, it increased significantly in the period from early June to the end of September (Figure 3). The climatic factors of the years shows that the mean rainfall from October of the last year to May of the following year was low, and the one from June to the end of September was high. All these results indicates that *Neolamarckia cadamba* grew quickly in the rainy season.

At 2nd site, *Neolamarckia cadamba* grew best, followed by those at 1st site, and 3rd site, respectively. Matching this to the characteristics of soil at the sites shows that trees planted on the site with high content of OM and high Ndt grew best.

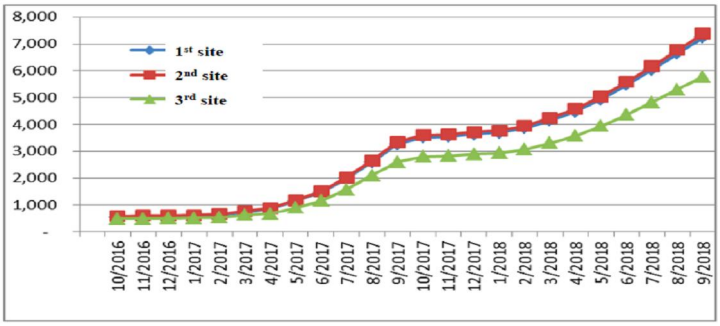
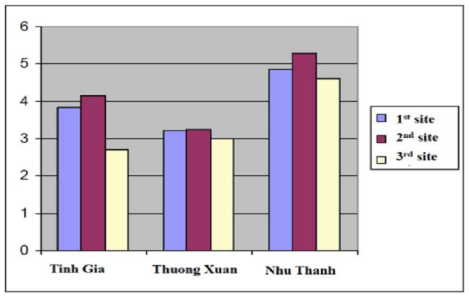


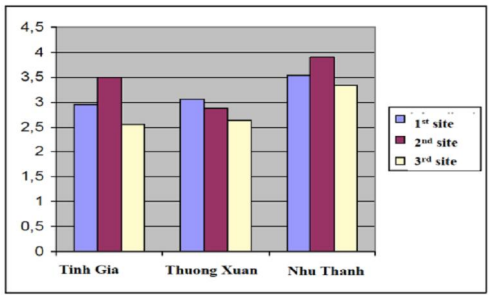
Figure 3. *The mean diameter of tree trunks in Tinh Gia*

3.2.3. Growth of Neolamarckia cadamba after 24 months of planting

Studying the growth ability of *Neolamarckia cadamba* in 24 months of planting, the results are described in the Figure 4.



(a)



(b)

Figure 4*. (a) Mean diameter of trunk; (b) Mean height of Neolamarckia cadamba after 24 months of planting*

The results showed that in all three areas, *Neolamarckia cadamba* grew best at the 2nd site, followed by trees at the 1st site and trees at the 3rd site. *Neolamarckia cadamba* grew best in the soil with high total organic matter content OM (%) and high easily digestible protein content (Ndt). They grew best in Nhu Thanh and grew worst in Tinh Gia. Comparing OM and Ndt in soil of three districts, the indicators were relatively homogenous in all sites. However, the pH soil, which reflects the degree of acidic or alkaline soil, was disparate. In Tinh Gia, soil pH was from slightly acidic to neutral, ranging from 6.46 to 7.35. In Thuong Xuan, soil pH was medium acidic, ranging from 5.09 to 5.86. In Nhu Thanh, soil pH was strongly acidic, ranging from 4.6 to 4.84. Therefore, *Neolamarckia cadamba* grew best in strongly acidic soil.

3.2.4. Pests and diseases in Neolamarckia cadamba

In all three areas, only leaf-eating caterpillars appeared in the months of the first year with high air humidity (from February to April). Most of defoliated *Neolamarckia cadamba* were in Thuong Xuan (about 30% of defoliated leaf) as there are many shade trees around the sites. Pesticides used to kill caterpillers included Apphe 666EC and ACCETA. These helped *Neolamarckia cadamba* recovered and and growed stably.

3.2.5. Natural disasters resistance of Neolamarckia cadamba

Neolamarckia cadamba were not collapsed and died due to the rain, storms, whirlwinds and flood in 2017 and 2018. Meanwhile, many *Acacia auriculiformis* and other plant species were collapsed, uprooted and died because of these disasters in the areas surrounding the model.

3.3. Determination of suitable sites for planting Neolamarckia cadamba in Thanh Hoa province

Thanh Hoa province has 647,055 ha of forests and forestry, including 598,573 ha of forest land, 48,482 ha of bare land, and bare hills. The results of the map overlay show that the forest land has a slope of less than 25°, with an area of 131,915 ha of forest land. The sites which is suitable for planting *Neolamarckia cadamba* was determined based on the study results of *Neolamarckia cadamba* growth as well as the effects of factors on *Neolamarckia cadamba* and on using site maps, topographic maps and specialized software (Mapinfo, forest- tool, etc.). The area of the sites is 3,200 ha including 45 communes of 9 districts (Cam Thuy 410 ha, Lang Chanh 430 ha, Ngoc Lac 457 ha, Nhu Thanh 261 ha, Nhu Xuan 577 ha, Thach Thanh 195 ha, Thuong Xuan 625 ha, Tinh Gia 175 ha and Trieu Son 70 ha).

4. Conclusion

Neolamarckia cadamba is the easy growing and photophillic tree, highly adaptable to natural conditions in Thanh Hoa province. The tree grows fast in the months with the average rainfall ranging from 178.6 mm to 437.8 mm, with the average temperature from 24 °C to 30°C and with the average humidity from 65.9% to 87.9%.

Neolamarckia cadamba grows well in deep, moist arable layers, with pH ranging from acidity to slight alkalinity and with a high organic matter and high dissolved organic nitrogen content.

The capable areas of *Neolamarckia cadamba* planting and developing in Thanh Hoa province include 45 communes of 9 districts with the total of 3,200 ha (Cam Thuy 410 ha, Lang Chanh 430 ha, Ngoc Lac 457 ha, Nhu Thanh 261 ha, Nhu Xuan 577 ha, Thach Thanh 195 ha, Thuong Xuan 625 ha, Tinh Gia 175 ha and Trieu Son 70 ha).

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