Growth Situation Study at the Early Period of Afforestation of Environmental Protection Forests

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Keywords: Environmental protection forest; Stand improvement; Growth of tree; Clustering analysis

Abstract. In this study, we investigated and researched the growth situation of 18 kinds of tree species in the stand improvement plot of environmental protection forests along the hill which is behind the ceramics factory of Gaoming District, Foshan City, Guangdong Province, and we implemented growth situation comparison and cluster analysis of ground diameter, tree height, crown width and clear bole height about these18 kinds of tree species. The result showed that: *Michelia macclurei* and *Schima superba* grew the best and had the largest volume of comprehensive growth, and 12 tree species--*Ficus altissimo*, *Syzygium rehderianum*, *Heteropanax fragrans*, *Nerium indicum*, *Acronychia pedunculata*, *Mytilaria laosensis*, *Tutcheria championi*, *Ilex rotunda*, *Alstonia scholaris*, *Helicia cochinchinensis*, *Cinnamomum bodinieri* and *Carallia brachiata* grew well and had a relatively large volume of comprehensive growth with an initial fast-growing result, which could be applied in environmental protection forest.

1 Introduction

Environmental protection forest is a part of the ecological forest, which is a general title of forest affected by the city and its surrounding urban environment and could relieve the urban environmental pollution(Zhen Xuening et al., 2001), and have a variety of ecological function of powerful carbon absorption and oxygen release, plus powerful absorption and degradation of various harmful gases(Deng Cheng et al., 2015), and also plays an irreplaceable role in maintaining ecological balance and ecological aspects of security in the region(Li Zhihong et al., 2006). In ceramics factory and other industrial pollution forest land, people should do stand improvement toward the inefficient forest of poor resistance and weak adaptability, which it also an important measure to construct efficient environmental protection forests and improve the quality of urban forest and ecological environment. In this study, we investigated and researched the growth situation of 18 kinds of tree species in the stand improvement plot of environmental protection forests along the hill which is behind the ceramics factory of Gaoming District, Foshan City, Guangdong Province, and compared and screened their differences with the purpose of providing the basis for tree species selection of urban environmental protection for the Pearl River Delta and surrounding areas.

2 Materials and methods

2.1 Overview of the test plot

The test plot is located in Gaoming District, Foshan City, Guangdong Province. The south of the test plot is the ceramics plant with a relatively serious ceramic pollution. Our group monitored air quality of the pollution situation in November 2013, and set up two monitoring points with continuous monitoring of three days. The location map of the test plot and ceramics plant is shown in Figure 1. The result is shown in Table 1. As we can see, the indicators monitored include sulfur dioxide, particulate matter, cadmium and its compounds, fluoride and hydrogen chloride, etc. They

are all overpass primary or secondary standards.

2.2 Test Materials

In this study, we reviewed literatures, and integrated the research results of Foshan forestry science institute and South China Botanical Garden, etc, and took seedling sources conditions of nursery stock into account, and finally determined a total of 18 forest plantation species in this demonstration forest, and planted three types: Type 1, Ficus altissima(Fa), Carallia brachiata(Cb2), Heteropanax fragrans(Hf), Camellia oleifera(Co), Nerium indicum(Ni), Strophanthus divaricatus(Sd); Type 2 Alstonia scholaris(As), Tutcheria championi(Tc), Gordonia axillaris(Ga), Helicia cochinchinensis(Hc), Schima superb(Ss), Ilex rotunda(Ir); Type 3 Syzygium rehderianum(Sr), Michelia macclurei(Mm), Mytilaria laosensis(Ml), Symplocos laurina(Sl), Acronychia pedunculata(Ap), Cinnamomum bodinieri(Cb1). We selected nutrition bag seedlings of 2-year-old and 40-60cm height. And they were interplanted and replanted 60 per acre in the mixed and randomized way. The planting time was rainy day. The afforestation was completed before May 1, 2011. Test forest planting plan is shown as Figure 2.

2.3 Investigation and Research Methods

Three sample plots were set in each afforestation type, and each plot was with the specification of 20m × 20m and an area of 400m². There were nine sample plots in total, and these nine plots were compiled for 1-1, 1-2, 1-3; 2-1, 2-2, 2-3; 3-1, 3-2, 3-3. A blue plastic pipe was set up in each corner of the plot to establish a fixed standard after the establishment of the sample plot.

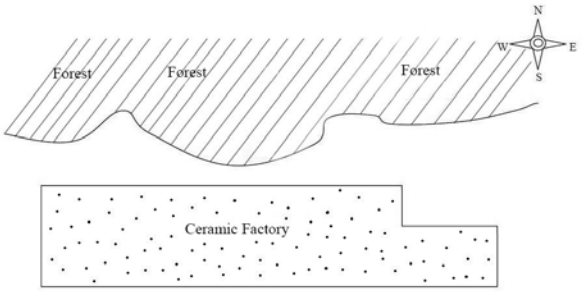

Figure 1. The location map of the test plot and ceramic plant

Table1 ShunCheng demonstration forest air quality monitoring results μg/cm3

monitoring items	monitoring point 1	monitoring point 1	primary standard limit	secondary standard limit
SO2	62	44	50	150
NOX	78	54	100	100
PM（<2.5μm）	71	53	35	75
Lead and its compounds	<0.25	<0.25	1	1
Cadmium and its compounds	<0.24	<0.24	0.005	0.005
Nickel and its compounds	<0.05	<0.05	0.05	0.05
Fluoride	8.8	3.7	1.2	2.0
Hydrogen chloride	306	322	250	250

Note: The primary and secondary limits refer to: national standard "Ambient Air Quality Standard" (GB3095-2012) and local standards "air pollutant discharge limits" of Guangdong Province (DB44 / 27-2001)

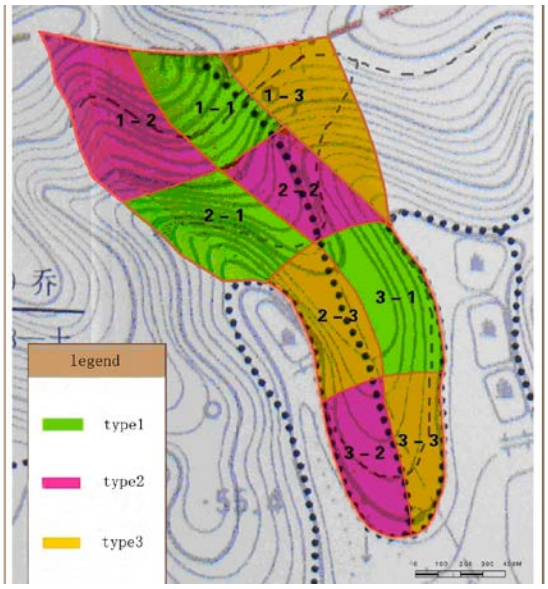

Figure 2 Test forest afforestation plan

Table 2 the basic situation of the sample plots

Sample plot number	Sample plot area	Aspect	Gradient	Slope position	Slope style
1-1	20m×20m	60°south by east	22°	middle and upper	slope
1-2	20m×20m	5°south by west	25°	middle and upper	slope
1-3	20m×20m	50°south by east	30°	middle and upper	slope
2-1	20m×20m	5°south by west	27°	middle and upper	slope
2-2	20m×20m	65°south by east	16°	middle and upper	slope
2-3	20m×20m	45°south by west	15°	middle and lower	slope
3-1	20m×20m	20°south by east	13°	middle and lower	slope
3-2	20m×20m	20°south by west	12°	middle and lower	slope
3-3	20m×20m	70°south by east	12°	middle and lower	slope

The stand improvement time of the test forest was in May 2011, and the survey of this research was conducted in May 2012 and July 2013. The main content of the survey contained ground diameter, tree height, crown width and clear bole height per mu and other growth index. The basic situations of the sample plots are listed in Table 2.

The tree height, crown width and clear bole height were measured by the steel rule, while ground diameter was measured by the vernier caliper (accuracy of 0.01 cm) for the stand improvement tree species we planted in the sample plots. We then sorted out average ground diameter, average tree height, average crown width and average clear bole height of the various species according to the survey raw data. And the tree height, ground diameter, crown width of the species were implemented cluster analysis by the use of SAS software version 8.1 according to the data we surveyed in 2013(Li Qiuli et al., 2012; Wang Biao et al., 2008; Wang Biaofang et al., 2009). Then we sorted out growth conditions of different species, and got differences in the growth rate of these 18 kinds of species in the sample plots.

3 Results and Analysis

3.1 Ground diameter growth comparisons of different afforestation trees in the stand improvement

The average ground diameter comparison results of 18 kinds of afforestation trees in different sample plots were shown in figure 3. The average ground diameter of each species were within 0.89-1.41cm when we surveyed in 2012, and by 2013, the average ground diameter of each species increased to 1.34-2.32cm with a certain ground diameter growth in each species. As what we can see from two data comparison, Alstonia scholaris and Michelia macclurei were the species which had the most highest increase in ground diameter growth with 119% and 112% respectively compared with the previous year; whereas Strophanthus divaricatus and Gordonia axillaris were the species which had the most lowest increase in ground diameter growth with only 31% and 39%respectively. According to the survey of 2013, six species had an increase in ground diameter of over 2.00cm, which were named Ficus altissima, Heteropanax fragrans, Nerium indicum, Acronychia pedunculata, Schima superba and Ilex rotunda.

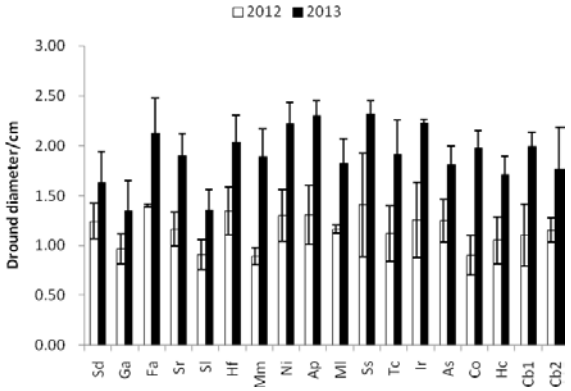

Figure 3 Average ground diameter comparisons of different species in the sample plots

3.2 Growth characteristics comparisons of tree height of different afforestation trees in the stand improvement

The average tree height comparison results of 18 kinds of afforestation trees in different sample plots were shown in Figure 4. We can see that, the average tree height of each species were within 0.50-1.09m when we surveyed in 2012, and by 2013, the average tree height of each species increased to 0.93-1.88m with a certain tree height growth in each species. As what we can see from two data comparison, Michelia macclurei and Symplocos laurina were the species which had the most highest increase in tree height growth with 200% and185% respectively compared with the previous year; whereas Ilex rotunda and Nerium indicum were the species which had the most lowest increase in tree height growth with only 17% and 32%respectively. According to the survey of 2013, 7 species had an increase in tree height of over 1.50m, which were named Syzygium rehderianum, Heteropanax fragrans, Michelia macclurei, Acronychia pedunculata, Schima superba, Cinnamomum bodinieri and Tutcheria championi.

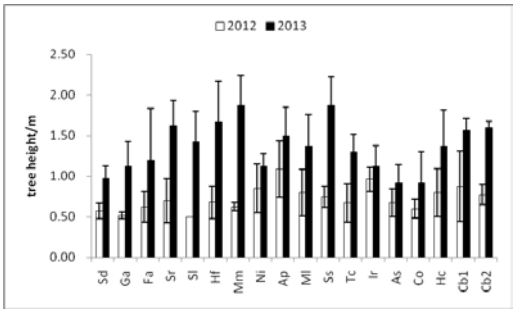

Figure 4 Average tree height comparisons of different species in the sample plots

3.3 Growth characteristics comparisons of crown width of different afforestation trees in the stand improvement

The average crown width comparison results of 18 kinds of afforestation trees in different sample plots were shown in Figure 5. We can see that, the average crown width of each species were within 0.21m-0.53m when we surveyed in 2012, in which Strophanthus divaricatus and Camellia oleifera were among the top with an average crown width of 0.53m. By 2013, the average crown width of each species increased to 0.43m-1.03m with a certain tree height growth in each species, in which Strophanthus divaricatus, Symplocos laurina, Michelia macclurei, Mytilaria laosensis, Schima superba, Helicia cochinchinensis and Cinnamomum bodinieri all had a relatively large increase of over 0.80m. As what we can see from two data comparison, Symplocos laurina and Schima superba were the species which had the most highest increase in crown width growth with 4.12 times and 3.58 times respectively. As we can see from figure 5 and according to the survey of 2013, the species which had the largest differences of crown width growth were Helicia cochinchinensis, following by Mytilaria laosensis and Syzygium rehderianum.

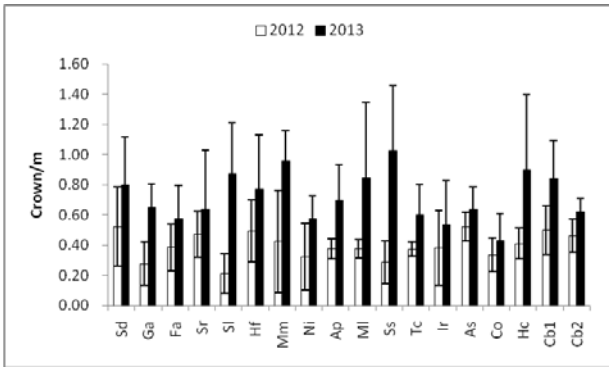

Figure 5 Average tree width comparisons of different species in the sample plots

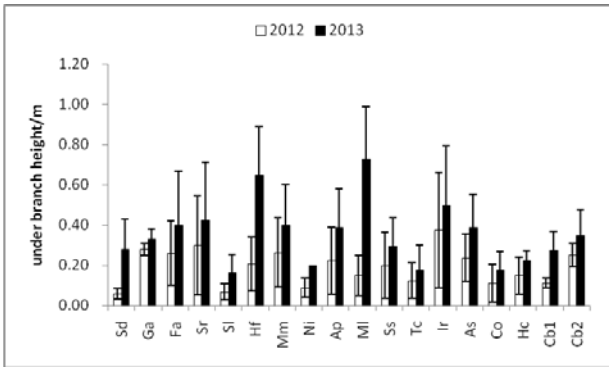

Figure 6 Average clear bole height comparisons of different species in the sample plots

3.4 Growth characteristics comparisons of clear bole height of different afforestation trees in the stand improvement

The average clear bole height comparison results of 18 kinds of afforestation trees in different sample plots were shown in Figure 6. We can see that, the average clear bole height of each species were within 0.06-0.38m when we surveyed in 2012, in which Ilex rotunda was the first one with an average clear bole height of 0.38m. By 2013, the average clear bole height of each species increased to 0.16-0.73m with a certain tree height growth in each species, in which Heteropanax fragrans, Mytilaria laosensis and Ilex rotunda all had a relatively large increase of over 0.50m. As what we can see from two data comparison, Mytilaria laosensis and Strophanthus divaricatus were the species which had the most highest increase in clear bole height growth with 4.87 times and 4.67 times respectively. As we can see from figure 5 and according to the survey of 2013, the species which had the largest differences of clear bole height growth were Ilex rotunda and Syzygium rehderianum.

3.5 Cluster analysis of growth rates of different species

Cluster analysis is a multivariate statistics analysis method processing aggregation classification based on the similarity between quantitative entities, which has a long history of application in ecology and environmental science(Potashev K et al., 2014). The growth situation of ground diameter, tree height, and crown width of 18 species in all sample plots were all implemented cluster analysis, and the results are shown in Figure 7.

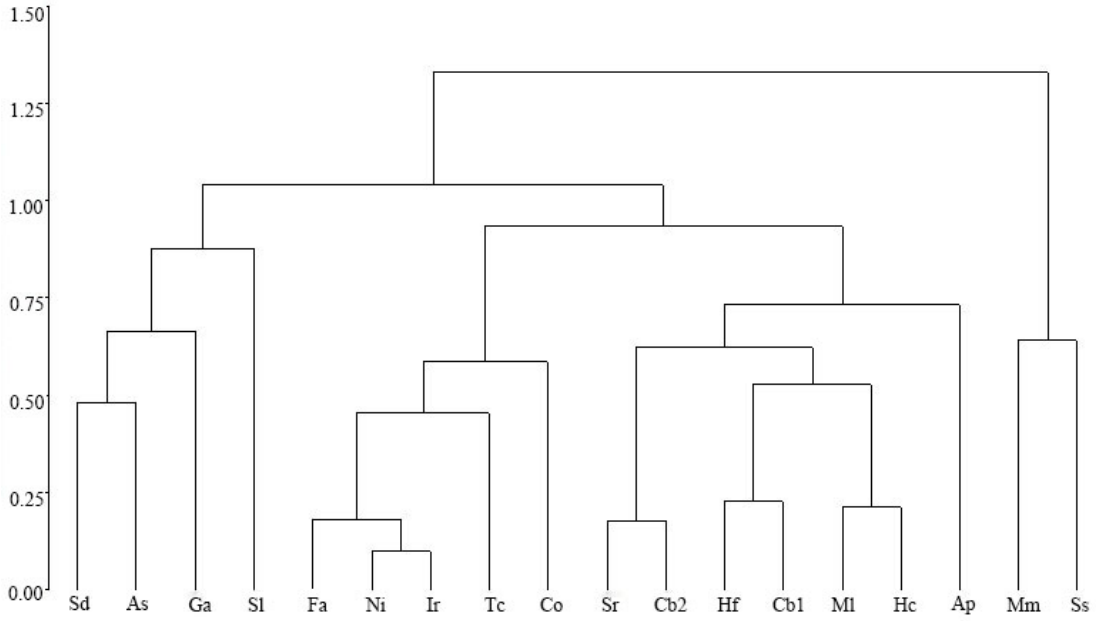

Figure 7 Cluster analysis diagrams of growth rates of different species

According to Figure 7, if we define the threshold value as 1.0, then the 18 species could be divided into three categories.

The first category: Michelia macclurei and Schima superba belonging to fast growing species;

The second category: Ficus altissima, Syzygium rehderianum, Heteropanax fragrans, Nerium indicum, Acronychia pedunculata, Mytilaria laosensis, Tutcheria championi, Ilex rotunda, Alstonia scholaris, Helicia cochinchinensis, Cinnamomum bodinieri, Carallia brachiata. They are general growing species.

The third category: Strophanthus divaricatus, Gordonia axillaris, Symplocos laurina and Camellia oleifera. These four species grow slow.

4 Conclusions and discussions

4.1 Early Growth Assessment to afforestation trees after stand improvement

In this study, we used quantitative analysis for the average ground diameter, average tree height, average crown width and average clear bole height of each rehabilitation species in the sample plots during the forest rehabilitation. We can see from the contrastive analysis of the data above, most of the tree species have survived, and each trees species showed a relatively suitable growth, although the growth rate varied. And for the native trees, the growth difference is relatively large in different species(Zhuang Xueying et al., 2001; Lai Zhitian et al., 2003; Zhu Hongguang et al., 2014; Gan Limei, 2009; Wang Xiang et al., 2012;).

4.2 Comprehensive assessment to afforestation trees after stand improvement

At the beginning of the growth point, Michelia macclurei and Schima superba had the largest growth volume, and grew the best, while Ficus altissima, Syzygium rehderianum, Heteropanax fragrans, Nerium indicum, Acronychia pedunculata, Mytilaria laosensis, Tutcheria championi, Ilex rotunda, Alstonia scholaris, Helicia cochinchinensis, Cinnamomum bodinieri, Carallia brachiata followed, and grew relatively well. All the 14 species mentioned above had a good planting effect at the early period and played a significant role in realizing short-term effect in ShunCheng stand improvement. Although the comprehensive growth of other species was slow, their long-term

growth, including other ecological characteristics was still worthy of further establishment of indicators and screening study.

Taking growth situation of all species in the sample plots and the improvement effect of reforming the forest into consideration, the tree spices we chose for stand improvement were appropriate and grew relatively well. But the trees age in this survey was young, and there may be different changes as these trees growing in the future. So it still needs further study.

5 Acknowledgements

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This study was partially supported by Foundation of National Forest Public Welfare Project (No. 201004042).

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