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Possible Planting Areas for Golden Camellia - *Camellia impressinervis* in Vietnam

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Authors' contributions

This work was carried out in collaboration among all authors. Author TVD, NVT, PDT, TDM, NTT, DVT, DTD, MTL, NTTP, NVK, VTL, NHT, HTS, TNB, HTL and VVT gathered information and conducted mapping. Author TVD wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Camellia impressinervis is known as a golden camellia, naturally distributing in China and Vietnam. Leaves and flowers of golden camellias contain active ingredients such as polysaccharides, polyphenols, saponins, and flavonoids. It was found to be able to inhibit the transplanted cancer, lower blood lipid, lower cholesterol, and prevent atherosclerosis. Market price of dry flowers of golden camellias in Vietnam is high, up to 700 US$/kg. This work was to identify suitable planting areas for *C. impressinervis* in Vietnam. Natural conditions, where *C. impressinervis* naturally distributes, were used for mapping, including elevation above sea level, annual precipitation, and annual air temperature. Each condition was classified to four levels as "very suitable", "suitable", "less suitable", and "not suitable" for planting. Three corresponding digital maps were used for mapping. The results indicated that 72,781 ha accounting for 32.3% total land area of the study site was classified as "very suitable" for planting *C. impressinervis*. The "suitable" areas accounted for 34.2% and the not suitable areas accounted for 33.5% total land area. There was no area belonging to "less suitable". It is recommended that *C. impressinervis* should be planted in "very suitable" areas and may be extended some to "suitable" areas. However, it should be widely planted only after carefully studying on cultivar selection, seedling production, and planting and tending techniques with consultation by local authorities.

Keywords: Active ingredient; golden camellia; natural condition; poverty reduction; suitable area.

1. INTRODUCTION

Camellia impressinervis Hung T. Chang & S. Ye Liang is known as a golden camellia [1-2], which has natural distribution in Southern China and North Vietnam and is classified as a critically endangered species [3]. The species is classified as an evergreen shrub or small-sized tree, which may reach up 7 m tall at maturity (Fig. 1). It has yellow flowers of up to 5 cm diameter. *C. impressinervis* is a shade tolerant species, which naturally distributes in evergreen broadleaved forests [4]. It prefers growing in high moisture soil and high air humidity areas.

Like green tea (*Camellia sinensis*), leaves and flowers of *C. impressinervis* have been used to make tea by soaking in hot water [4]. Both fresh and dry products can be used. However, dry products are preferred as they can be stored for a long time. Dry flowers of 2-3% moisture can be stored for several years. Traditionally, fresh flowers are soaked in alcohol for several months before use, which is reported to improve health for drinkers. *C. impressinervis* tea can be used daily through without getting stale and smell like green tea. Several researches indicated that the extracts from golden camellias have antioxidant activities, superoxide anions, and hydroxyl free radicals scavenging assays [5]. They can be used to treat sore throat, diarrhea, irregular menstruation, and cancer prevention [6].

Currently, market price of dry leaves and flowers of golden camellias is quite high, much higher than that of green tea. It cost 600-700 US$/ 1 kg dry flowers and 40-50US$/ 1 kg dry leaves in Vietnam [4]. While, it cost 320 US$/ 1 kg dry flowers in China [7]. A field record indicated a tree of *C. impressinervis* of 1.2 m tall, which was planted by local people without properly tending, bloomed 130 flowers in a year, equaling 0.3 kg dry flowers [4]. These have been attracting local people to grow golden camellias for poverty reduction and economic development. To grow *C. impressinervis* successfully, selecting suitable planting areas is the first step beside many others such as producing good seedlings, planting and tending techniques etc.

The objective of this study was to identify suitable planting areas for *C. impressinervis* in North Vietnam.

2. MATERIALS AND METHODS

2.1 Study Site

C. impressinervis is known as having natural distributions in Southern China and North Vietnam [1-3]. Recent field investigations indicated natural distributions of *C. impressinervis* in Thach An, Phuc Hoa, and Ha Lang districts of Cao Bang province, Vietnam [4] (Fig. 2). In addition, *C. impressinervis* was recorded to be planted in Thach An district and started blooming recently [4]. Therefore, in this study only five districts (Fig. 2) of Cao Bang province were included for mapping suitable planting areas. Quang Uyen and Trung Khanh

districts were included as it is believed that *C. impressinervis* could grow in these two districts, which share borderlines with Phuc Hoa and Ha Lang (Fig. 2).

2.2 Gathering Natural Conditions of *C. impressinervis*

Natural information including elevation above sea level, air temperature, and precipitation, where *C. impressinervis* has natural distributions, was gathered [4]. Elevation is a prerequisite condition for growing a species, as no species can grow well in all elevation zones because of changing of climate conditions by elevation changes.

Geographical locations, where *C. impressinervis* was reported to have natural distributions, were collected [4]. It was then located on digital maps to gain information on elevation above sea level, air temperature, and precipitation. These conditions were used to classify to different categories of suitability for planting *C. impressinervis*.

2.3 Mapping Technique

Mapping techniques have been widely used to study species distribution ranges [8], and identify plant diversity [9] and tree-potential planting sites [10]. The techniques use information represented on digital maps to find out the met areas.

Three digital map layers were used for mapping, which represent each of three main conditions; (1) topographical map for elevation, (2) precipitation map, and (3) temperature map. Each of three main conditions was classified to four levels including (a) “very suitable”, (b) “suitable”, “less suitable”, and (c) “not suitable”. Mapping techniques were conducted as following:

- If only one of three main conditions belongs to “not suitable”, entire areas are classified as “not suitable area”.
- If all three main conditions belong to “less suitable”, entire areas are classified as “less suitable area”.
- If all three main conditions belong to “suitable”, entire areas are classified as “suitable area”.
- If all three main conditions belong to “very suitable”, entire areas are classified as “very suitable area”.

Areas are then summarized for each district to generate total area of each category. On map, borderlines are marked to commune levels.

3. RESULTS

3.1 Natural Conditions of *C. impressinervis*

C. impressinervis naturally distributes in elevation range of 194–448 m above sea level, air temperature of 20–22°C, and annual precipitation of 1,400–1,554 mm. In its natural distribution areas, the minimum air temperature recorded was 13.1°C and maximum air temperature was 29.8°C. *C. impressinervis* distributes in evergreen broadleaved forests, where there is no or only some trees of fully-shedding leaf species. The species can be found in both primary forest, where there are no signals of human disturbance, or in secondary forest recovered after selective logging or shifting cultivation. The forest cover is important for growth of *C. impressinervis*, which must be >40%. The species prefers to grow in wet condition, high moisture soils in areas close to streams and/or water bodies, and deep layer soil. However, it is also found growing in dry and shallow layer soil. *C. impressinervis* has shallow root system and number of fineroots (roots with diameter ≤2 mm) are limited. This may lead to limited capacity for water absorbing and therefore *C. impressinervis* prefers growing in high moisture soil for life sustainability.

C. impressinervis was planted in gardens of local people with a limited number of individuals (less than 500 trees). Which were dug up from natural forests and transplanted. After transplanting 5 years, some trees started blooming. However, productivity was low and there was no record of marketing flowers and leaves. Planted trees are generally not shaded properly, where they have less green leaves. While, shaded ones have more green leaves like *C. impressinervis* trees in natural forests.

3.2. Possible Planting Area

Each of three main conditions including elevation above sea level, annual precipitation, and annual air temperature was classified into four levels. The range of each level is shown in Table 1. “Very suitable” generally covers natural conditions where *C. impressinervis* has natural distribution. The ranges, then, are extended gradually upward and downward to form other three levels (Table 1).

Mapping by overlapping three digital maps of elevation above sea level, annual precipitation,

and annual air temperature resulted in a map of possible planting areas for *C. impressinervis* in North Vietnam (Fig. 2). Details of "very suitable", "suitable", "less suitable", and "not suitable" areas for each study districts were generated in Table 2. There was no area belonging to "less suitable". The "very suitable" area was 72,781 ha, accounting for 32.3% total land area of these five districts. The "suitable" area was 77,048 ha, accounting for 34.2%, and the "not suitable" area was 75,355 ha, accounting for 33.5% (Table 2). Thach An district, where numerous populations of *C. impressinervis* were found, has highest area (35,528 ha) belonging to "very suitable", accounting for nearly 50% of total "very suitable" areas of those five study districts. While, Trung Khanh district, sharing borderline with China, has lowest area (1,300 ha) belonging to "very suitable" as this district locates on high elevation land.

4. DISCUSSION

In intensive cultivation, air temperature and humidity, and soil moisture can be controlled by growing golden camellias in greenhouse [11]. However, it is costly and seems not suitable for practical application in poor conditions of local mountainous areas North Vietnam as in the present study site. Elevation above sea level is a prerequisite condition [12], which we cannot modify like temperature and humidity. Therefore, three conditions including air temperature, annual precipitation, and elevation above sea level were recognized as prerequisite conditions for planting *C. impressinervis* in Vietnam. An area must meet requirement of all three conditions for *C. impressinervis* to grow well. Therefore, mapping technique of overlapping of prerequisite conditions to look for met areas is the best one to find out possible planting areas for *C. impressinervis*.

Table 1. Classifying conditions for mapping

Main condition	Level			
	Very suitable	Suitable	Less suitable	Not suitable
Elevation above sea level (m)	170–450	150–550	<150 and 550–700	>700
Annual precipitation (mm)	1,400–1,600	1,350–1,800	1,200–1,350 and 1,800–2,000	<1,200 and >2,000
Annual air temperature (°C)	20–22	19–22	17–19 and 22–23	<17 and >23

Table 2. Potential planting areas (ha) by districts

No	District	Very suitable	Suitable	Not suitable
1	Ha Lang	13,411	18,707	13,673
2	Phuc Hoa	11,246	11,486	2,472
3	Quang Uyen	11,296	11,745	15,387
4	Thach An	35,528	19,510	14,043
5	Trung Khanh	1,300	15,600	29,779
Total (ha)		**72,781**	**77,048**	**75,355**
Percentage of Total land area (%)		**32.3**	**34.2**	**33.5**

Fig. 1. A *Camellia impressinervis* tree (left), flower (middle), and fruit (right)

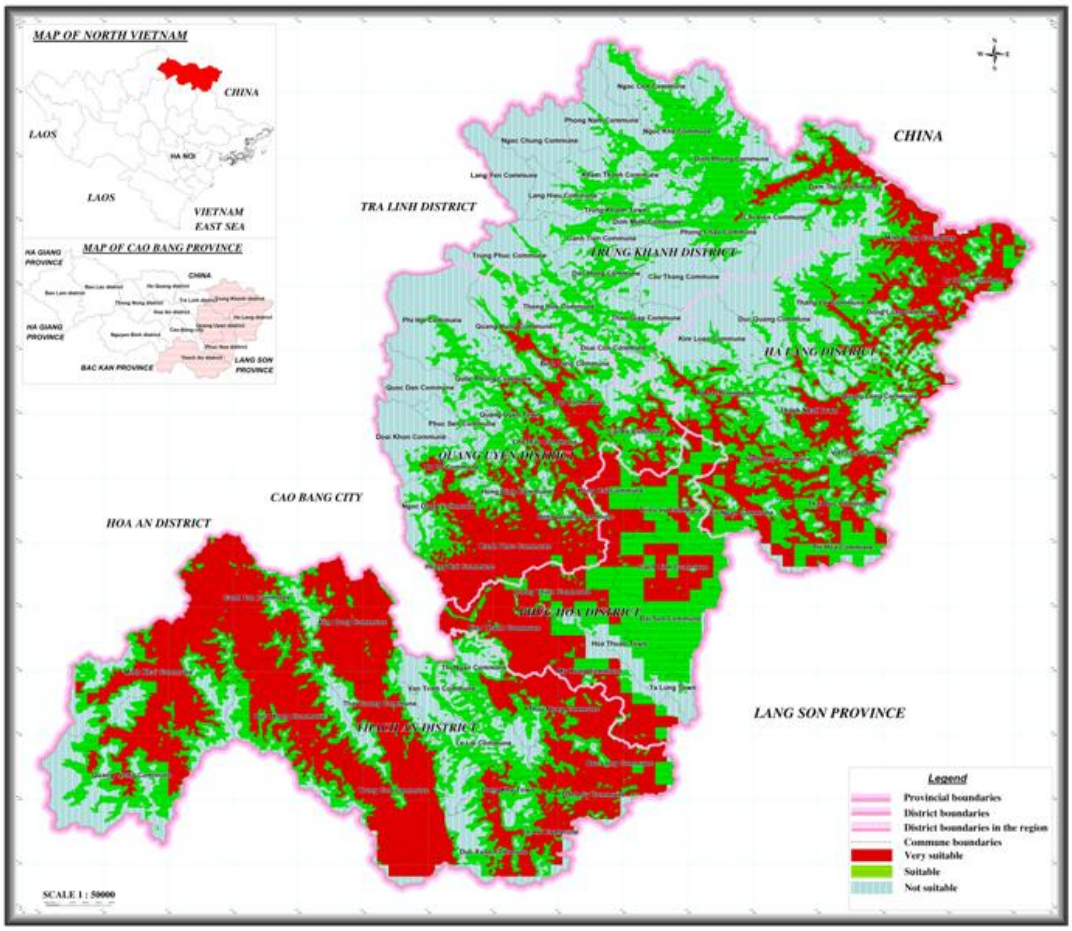

Fig. 2. Map of potential planting areas for *Camellia impressinervis* in Vietnam

C. impressinervis is classified as a shrub or small-sized tree, which is shorter than 7 m tall at maturity [2,4]. It is a shade-tolerant species, which can grow well only under shade in whole life. Therefore, forest canopy cover is important for planting *C. impressinervis*, similar to seedling and sapling stages of other tree species [13]. It is recommended to grow *C. impressinervis* under suitable shade of natural forests and plantations with canopy cover of 40–60%. If ones grow *C. impressinervis* on bared land, shading by growing other tree species is required. Otherwise, trees may grow badly as effect of direct sunlight on chlorophylls and photosynthesis process [14]. Soil is also important for growing *C. impressinervis*, which prefers growing in fertile soil. However, ones may grow *C. impressinervis* in less fertile soil. Then, fertilizers should be applied for better growths [15] and higher flower productivity. It is recommended that *C. impressinervis* should be planted only in “very suitable” areas. However, such areas may fall in protection forests, where no actions are allowed by law and regulations for natural forest protections. Therefore, planters should consult local authorities for permission on planting sites in advances. In addition, technique guidelines for planting and tending should be transferred through learning by doing, which is known as the best way for ethnic people, who are interested in planting *C. impressinervis*.

Until recently, there have no records of natural distributions of *C. impressinervis* in Quang Uyen and Trung Khanh districts (Fig. 2). However, they share borderlines with Phuc Hoa and Ha Lang districts of Vietnam and China, where *C. impressinervis* has natural distributions [3-4]. Therefore, it is believed that Quang Uyen and Trung Khanh districts could be suitable for planting. For practical application, *C. impressinervis* should be planted first in Thach An and Phuc Hoa districts, then Ha Lang and other districts (Fig. 2).

5. CONCLUSION AND RECOMMENDATION

C. impressinervis is a potential species for poverty reduction in mountainous areas. Potential planting areas in North Vietnam for this species are shown with total "very suitable" areas of 72,781 ha. To grow *C. impressinervis* successfully, studies on selecting plus trees for flowers, techniques for producing good seedlings, planting and tending should be carried out before practical application in large scale.

A comprehensive developing plan for *C. impressinervis* should be initiated by collaboration among scientists, policymakers, market developers, and growers. The plan should ensure the best quality of *C. impressinervis* confirmed by scientists, market stability by market developers, advoiding overplanting by policymakers and growers. The final is stability of benefits of all concerned stakeholders. To improve commercial values of *C. impressinervis*, studies on its antioxidative properties should be conducted as such studies have been carried out for other golden camellias; *Camellia chrysantha* [5,16], *Camellia nitidssimas* [17-18], and *Camellia euphlebia* [19].

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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