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

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33 **ABSTRACT**

34 *Camellia impressinervis* is known as a golden camellia, naturally distributing in China and

35 Vietnam. Leaves and flowers of golden camellias contain active ingredients such as

36 polysaccharides, polyphenols, saponins, and flavonoids. It was found to be able to inhibit the

37 transplanted cancer, lower blood lipid, lower cholesterol, and prevent atherosclerosis. Market

38 price of dry flowers of golden camellias in Vietnam is high, up to 700US$/kg. This work was to

39 identify suitable planting areas for *C. impressinervis* in Vietnam. Natural conditions, where *C.*

40 *impressinervis* naturally distributes, were used for mapping, including elevation above sea level,

41 annual precipitation, and annual air temperature. Each condition was classified to four levels as

42 "very suitable", "suitable", "less suitable", and "not suitable" for planting. Three corresponding

43 digital maps were used for mapping. The results indicated that 72,781 ha accounting for 32.3%

44 total land area of the study site was classified as "very suitable" for planting *C. impressinervis*.

45 The "suitable" areas accounted for 34.2% and the not suitable areas accounted for 33.5% total

46 land area. There was no area belonging to "less suitable". It is recommended that *C.*

47 *impressinervis* should be planted in "very suitable" areas and may be extended some to

48 "suitable" areas. However, it should be widely planted only after carefully studying on cultivar

49 selection, seedling production, and planting and tending techniques with consultation by local

50 authorities.

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1. INTRODUCTION

55 *Camellia impressinervis* Hung T. Chang & S. Ye Liang is known as a golden camellia [1-2],

56 which has natural distribution in Southern China and North Vietnam and is classified as a

57 critically endangered species [3]. The species is classified as an evergreen shrub or small-sized

58 tree, which may reach up 7 m tall at maturity (Fig. 1). It has yellow flowers of up to 5 cm

59 diameter. *C. impressinervis* is a shade tolerant species, which naturally distributes in evergreen

60 broadleaved forests [4]. It prefers growing in high moisture soil and high air humidity areas.

61 Like green tea (*Camellia sinensis*), leaves and flowers of *C. impressinervis* have been used to

62 make tea by soaking in hot water [4]. Both fresh and dry products can be used. However, dry

63 products are preferred as they can be stored for a long time. Dry flowers of 2-3% moisture can

64 be stored for several years. Traditionally, fresh flowers are soaked in alcohol for several months

65 before use, which is reported to improve health for drinkers. *C. impressinervis* tea can be used

66 daily through without getting stale and smell like green tea. Several researches indicated that

67 the extracts from golden camellias have antioxidant activities, superoxide anions, and hydroxyl

68 free radicals scavenging assays [5]. They can be used to treat sore throat, diarrhea, irregular

69 menstruation, and cancer prevention [6].

70 Currently, market price of dry leaves and flowers of golden camellias is quite high, much

71 higher than that of green tea. It cost 600-700 US$/ 1 kg dry flowers and 40-50US$/ 1 kg dry

72 leaves in Vietnam [4]. While, it cost 320 US$/ 1 kg dry flowers in China [7]. A field record

73 indicated a tree of *C. impressinervis* of 1.2 m tall, which was planted by local people without

74 properly tending, bloomed 130 flowers in a year, equaling 0.3 kg dry flowers [4]. These have

75 been attracting local people to grow golden camellias for poverty reduction and economic

76 development. To grow *C. impressinervis* successfully, selecting suitable planting areas is the

77 first step beside many others such as producing good seedlings, planting and tending techniques

78 etc.

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

2. MATERIALS AND METHOD

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*.

103 **2.3 Mapping Technique**

104 Mapping techniques have been widely used to study species distribution ranges [8], and

105 identify plant diversity [9] and tree-potential planting sites [10]. The techniques use information

106 represented on digital maps to find out the met areas.

107 Three digital map layers were used for mapping, which represent each of three main conditions;

108 (1) topographical map for elevation, (2) precipitation map, and (3) temperature map. Each of

109 three main conditions was classified to four levels including (a) "very suitable", (b) "suitable",

110 "less suitable", and (c) "not suitable". Mapping techniques were conducted as following:

111 • If only one of three main conditions belongs to "not suitable", entire areas are classified

112   as "not suitable area".

113 • If all three main conditions belong to "less suitable", entire areas are classified as "less

114   suitable area".

115 • If all three main conditions belong to "suitable", entire areas are classified as "suitable

116   area".

117 • If all three main conditions belong to "very suitable", entire areas are classified as

118   "very suitable area".

119 Areas are then summarized for each district to generate total area of each category. On map,

120 borderlines are marked to commune levels.

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122 **3. RESULTS**

123 **3.1 Natural Conditions of *C. impressinervis***

124 *C. impressinervis* naturally distributes in elevation range of 194–448 m above sea level, air

125 temperature of 20–22°C, and annual precipitation of 1,400–1,554 mm. In its natural distribution

126 areas, the minimum air temperature recorded was 13.1°C and maximum air temperature was

127   29.8^{o}C. *C. impressinervis* distributes in evergreen broadleaved forests, where there is no or only

128   some trees of fully-shedding leaf species. The species can be found in both primary forest,

129   where there are no signals of human disturbance, or in secondary forest recovered after

130   selective logging or shifting cultivation. The forest cover is important for growth of *C.*

131   *impressinervis*, which must be >40%. The species prefers to grow in wet condition, high

132   moisture soils in areas close to streams and/or water bodies, and deep layer soil. However, it is

133   also found growing in dry and shallow layer soil. *C. impressinervis* has shallow root system and

134   number of fineroots (roots with diameter ≤2 mm) are limited. This may lead to limited capacity

135   for water absorbing and therefore *C. impressinervis* prefers growing in high moisture soil for

136   life sustainability.

137   *C. impressinervis* was planted in gardens of local people with a limited number of individuals

138   (less than 500 trees). Which were dug up from natural forests and transplanted. After

139   transplanting 5 years, some trees started blooming. However, productivity was low and there

140   was no record of marketing flowers and leaves. Planted trees are generally not shaded properly,

141   where they have less green leaves. While, shaded ones have more green leaves like *C.*

142   *impressinervis* trees in natural forests.

143

144   **3.2. Possible Planting Area**

145   Each of three main conditions including elevation above sea level, annual precipitation, and

146   annual air temperature was classified into four levels. The range of each level is shown in Table

147   1. "Very suitable" generally covers natural conditions where *C. impressinervis* has natural

148   distribution. The ranges, then, are extended gradually upward and downward to form other

149   three levels (Table 1).

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

151   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 tall "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 prerequisite condition [12], which we cannot modify like temperature and humidity. Therefore, three conditions including air temperature, precipitation, and elevation 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*.

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–

178   60%. If ones grow *C. impressinervis* on bared land, shading by growing other tree species is

179   required. Otherwise, trees may grow badly as effect of direct sunlight on chlorophylls and

180   photosynthesis process [14]. Soil is also important for growing *C. impressinervis*, which prefers

181   growing in fertile soil. However, ones may grow *C. impressinervis* in less fertile soil. Then,

182   fertilizers should be applied for better growths [15] and higher flower productivity. It is

183   recommended that *C. impressinervis* should be planted only in "very suitable" areas. However,

184   such areas may fall in protection forests, where no actions are allowed by law and regulations

185   for natural forest protections. Therefore, planters should consult local authorities for permission

186   on planting sites in advances. In addition, technique guidelines for planting and tending should

187   be transferred through learning by doing, which is known as the best way for ethnic people,

188   who are interested in planting *C. impressinervis*.

189   Until recently, there have no records of natural distributions of *C. impressinervis* in Quang

190   Uyen and Trung Khanh districts (Fig. 2). However, they share borderlines with Phuc Hoa and

191   Ha Lang districts of Vietnam and China, where *C. impressinervis* has natural distributions [3-

192   4]. Therefore, it is believed that Quang Uyen and Trung Khanh districts could be suitable for

193   planting. For practical application, *C. impressinervis* should be planted first in Thach An and

194   Phuc Hoa districts, then Ha Lang and other districts (Fig. 2).

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196   **5. CONCLUSION AND RECOMMENDATION**

197   *C. impressinervis* is a potential species for poverty reduction in mountainous areas. Potential

198   planting areas in North Vietnam for this species are shown with total "very suitable" areas of

199   72,781 ha. To grow *C. impressinervis* successfully, studies on selecting plus trees for flowers,

200   techniques for producing good seedlings, planting and tending should be carried out before

201   practical application in large scale.

202   A comprehensive developing plan for *C. impressinervis* should be initiated by collaboration

203 among scientists, policymakers, market developers, and growers. The plan should ensure the

204 best quality of *C. impressinervis* confirmed by scientists, market stability by market developers,

205 advoiding overplanting by policymakers and growers. The final is stability of benefits of all

206 concerned stakeholders. To improve commercial values of *C. impressinervis*, studies on its

207 antioxidative properties should be conducted as such studies have been carried out for other

208 golden camellias; *Camellia chrysantha* [5, 16], *Camellia nitidssimas* [17-18], and *Camellia*

209 *euphlebia* [19].

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216 **COMPETING INTERESTS**

217 Authors have declared that no competing interests exist.

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269 **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 (^{o}C)	20–22	19–22	17–19 and 22–23	<17 and >23

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Table 2. Potential planting areas (ha) by districts

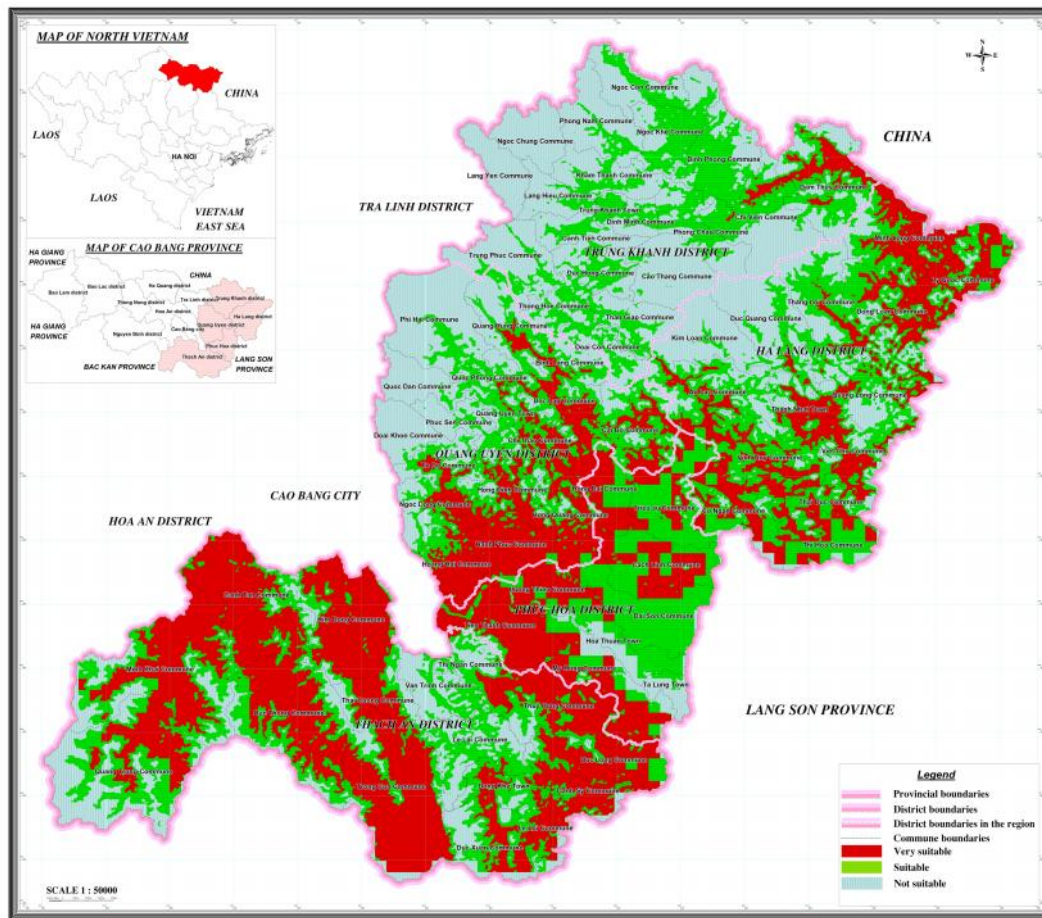| No	District	Very suitable	Suitable	Not suitable
1	Ha Lang	13,411	18,707	13,673
2	Phuc Hoa	11,246	11,486	2,472
3	Quang Uyen	11,296	11,745	15,387
4	Thach An	35,528	19,510	14,043
5	Trung Khanh	1,300	15,600	29,779
Total (ha)		**72,781**	**77,048**	**75,355**
Percentage of total land area (%)		**32.3**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

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

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