Minireview Paper

Golden Camellias: A Review

ABSTRACT

Golden camellias or yellow camellias are species belonging to genus *Camellia* L., family Theaceae. Fifty two species were described in southern China and Vietnam. Active ingredients such as polysaccharides, polyphenols, tea saponins, and flavonoids are well known characteristics of golden camellias. Its leaves and flowers have been long traditionally used for health improvement. It was found to be able to inhibit the transplanted cancer, lower blood pressure, lower blood lipid, lower cholesterol, and prevent atherosclerosis. Currently, it cost 320-700US$ per one kg of dry flowers. Such price attracts many local ethnic people to plant golden camellias for poverty reduction. This work reviews (1) species and natural distribution, (2) uses and healthcare values, (3) techniques for seedling production, planting and tending, and (4) opportunities and challenges for future development of golden camellias.

Comment [S1]: ?

Keywords: Active ingredient; *Camellia* L.; poverty reduction; shade-tolerant species; yellow flower.

1. SPECIES AND NATURAL DISTRIBUTION

Golden camellias or yellow camellias are shrubs and small-sized trees belonging to genus *Camellia* L [1], family Theaceae [2-8]. Golden camellias have light to heavy yellow flowers (Fig. 1) and are 3-12 m tall at maturity in natural distribution conditions. The size of flowers are different among species from 1 to 10 cm in diameter (Fig. 1). About 52 species (Table 1) of golden camellias have been described in southern China and Vietnam. Of which, nearly 40 species have natural distribution in Vietnam.

Golden camellias distribute in natural evergreen broadleaved forests [3-4, 7-14], where there are no or some trees shedding full leaves in winter/dry season. Golden camellias are shade-tolerant species, which can only grow well under shading condition in whole life. The species are usually found in natural forests with canopy cover of 30-80%. Generally, golden camellias distribute in elevation zone of 100-1,000 m above sea level, mainly focusing on elevation of 300-700 m. The species prefer growing in high moisture soil and high air humidity areas. Therefore, they are usually found in valleys, near streams, and water bodies. In some cases, trees are also found in dry soil, where they grow badly and are in small size.

Like other species in genus *Camellia* L., golden camellias have big-sized seeds, which are mainly dispersed by gravity [8, 13, 15]. Therefore, seedlings are usually found under or near crown of mother trees. If mother trees are found in upper slope then seedlings may be found further from mothers in downslope. In natural forests, seedlings/saplings (<1 m tall) may be found numerously however, number of adults (>2 m tall) are limited [16]. These indicate the success of natural regeneration is low, because of low competition capacity of golden camellia seedlings to surrounding vegetation. This may lead to threatened status of some species [17]. Golden camellias are found to have clustered distribution in nature. For the adult individuals, stems distributing in high forest cover areas have less number of flowers than stems distributing in low forest cover areas (high sunlight areas). Generally, in high sunlight areas flowers are more yellow than that in low sunlight areas [15]. This may indicate the importance of sunlight in forming buds and flowers of golden camellias. Therefore, canopy should be open in plantations of golden camellias for higher flower productivity and flower quality.

Golden camellias have shallow root system and limited number of fine roots (roots with diameter ≤2 mm), which absorb water and nutrient for tree's life [18]. Such characteristic

Comment [S2]: The sizes of flowers are

Comment [S3]: As a result of these natural regeneration will be low

Comment [S4]: Generally in areas with high rat of sunlight

Comment [S5]:

Comment [S6]: remove

may result in low competition capacity for moisture, nutrients, and tree's anchoring. Therefore, tending should be conducted carefully at seedling stage to minimize competition, which may result in higher survival rate of seedlings. In addition, seeds of golden camellias are also food for rodents and other wildlife, this may cause low seedling density in nature.

2. USES AND HEALTHCARE VALUES

Like green tea (*Camellia sinensis*), golden camellias have been traditionally used to make tea for its beneficial properties and dry flowers are used more frequently than leaves [15]. Both fresh and dry flowers and leaves can be used. However, dry products are preferred as they can be stored for a long time. Flowers are also soaked in alcohol, which is reported to improve health for drinkers. Recently, some cosmetics are made from flower and leaf extracts of golden camellias such as golden silk oil, organic golden camellia oil, and facial cream.

Species in genus *Camellia* contain a variety of physiologically active ingredients as polysaccharides, polyphenols, tea saponins, and flavonoids [19-22]. Clinical findings showed that the camellias could inhibit the transplanted cancer, lower blood pressure, lower blood lipid and lower cholesterol, and prevent atherosclerosis [23-24]. Research has demonstrated that the extracts from golden camellias have antioxidant activities, superoxide anions, and hydroxyl free radicals scavenging assays [21]. Golden camellias such as *C. nitidissima* have been used to treat sore throat, diarrhea, high blood pressure, irregular menstruation, and cancer prevention [19]. Studies on *C. euphlebia*, a golden camellias widely planted in Vietnam [15], indicated that leaves can be used for treatment of dysentery, hypertension, diarrhea, faucitis, and irregular menstruation [24]. While, its extracts are reported to possess anticarcinogenic, antioxidant, hypoglycemic, and hypolipidemic properties [25-26].

Main phytochemicals and compounds [27-29] isolated from golden camellias include α-spinasteryl-β-D-glucopyranoside, stigmasta-7,22-diene-3-O-[α-L-arabinopyranosyl (1→2)]-β-D-galactopyranoside, kaempferol 3-O-[2-O-(trans-p-coumaroyl)-3-O-α-D-glucopyranosyl]-α-D-glucopyranoside, aromadendrin, catechin, phlorizin 4'-O-β-D-glucopyranoside, (3R,6R,7E)-3-hydroxy-4,7-megastigmadien-9-one, dodecanoic acid, 3β-acetoxy-20-lupanol, and 3β,6α,13β-trihydroxyolean-7-one. Aqueous extracts from golden camellias have been used for study on their effects to mice [24] showing anxiolytic and

antidepressant activities, and for study on pyocyanin production and motility of *Pseudomonas aeruginosa* [28-29], an opportunistic pathogen of plants, animals, and humans [30].

3. TECHNIQUES FOR SEEDLING PRODUCTION, PLANTING AND TENDING

In 1990s individuals of golden camellias were dug up from natural forests and transplanted in suitable areas in south China and north Vietnam for flower purpose. Trees of all sizes were dug up, removed all branches and leaves to remain main stem of <1 m and root system of 30-40 cm in length. Root system was soaked in hormone IAA (Indole-3-acetic acid) or hormone IBA (Indole-3-butyric acid) with suitable concentration, and then transplanted. By this method, after planting 3-4 years trees started to bloom [15]. The activity has led to makeable reduce number of populations in the wild and is now prohibited. This may be a main reason leading to endangered status of some species [17]. In addition, collecting flowers in the wild has led to limited number of seedlings because of fruit reduction. Therefore, producing seedling from seeds seems to be difficult task recently. By producing seedlings from seeds, Hung and Lee [31] showed high germination rate of >90% for *C. nitidissima*. However, it is sexual propagation and therefore is not sure about the flower productivity and quality of next generation.

In recent years, cutting propagation have been conducted to produce seedlings. Branches of 1-2 years old were cut into segments of 7-10 cm in length which contain 2-3 leaves (Fig. 2). Each leaf was remained only 1/5-1/3 area, then suitable hormone such as IAA or IBA were used for rooting. The survival rate of cutting may reach 99% under greenhouse conditions [31]. While, experiment for *C. tamdaoensis* indicated that using hormone IBA at 1% resulted in rooting rate of 52.8% [32]. Ngo [33] indicated that *C. tonkinensis* has highest rooting rate of 83.3% at 1.5% IBA, rooting rate of 80.6% for *C. euphlebia* at 2.0% IBA, 77.8% for *C. tamdaoensis* at 1.5% IBA, and 83.3% for *C. cucphuongensis* at 2.0% IBA. Rooting medium and propagation season also effect on rooting rate, which indicated that using rooting medium of clean sand and propagating in spring are the best for golden camellias [34-35]. Others [35-36] indicated using hormone NAA (Naphthaleneacetic acid) is also suitable for cutting propagation of golden camellias, which resulted in >70% rooting rates. Controlling temperature and humidity by greenhouse and automatic spraying system (Fig. 2) in cutting propagation is important for high rooting rates, which must be in

Comment [S7]: vegetative propagation by stem cuttings

Comment [S8]: propagation season also have effect on rate of rooting

Comment [S9]: sterilized river sand

Comment [S10]: stem cuttings

Comment [S11]: ?

a range of 19-22^{o}C and >90% humidity [16, 33, 35-36].

Cutting propagation transfers original gene sources of mother to next generation. The best characteristics of mother such as high flower productivity, big-sized flower, and high contents of phytochemicals will be transferred to seedlings. Therefore, the first step should be selecting mother trees with plus characteristics on flower. However, until recently there have no records on mother tree selection in golden camellias [15]. To have best plantations in the future, selecting mother tree must be conducted carefully.

Comment [S12]: ?

Comment [S13]: There has been norecords

Golden camellias have been planted in greenhouses in China, where air temperature, humidity, and shading can be controlled automatically [31]. It indicated that keeping humidity at 85-90% and temperature at 20-26^{o}C during daytime and 5-10^{o}C lower during night time are the best. By these conditions, trees can produce buds two times and reach 40 cm in height a year. However, this is an intensive cultivation of golden camellias and is costly. There is requirement for cost-benefit analysis for this practical application.

Golden camellias have been widely planted under forest canopy, especially in secondary forest and pine plantation, which have canopy cover of 25-55% [15, 37-38]. However, they are also planted in bared land [15, 35, 38]. In that case, shading is required. Shading can be carried out artificially by greenhouses [31] or by planting other tree species [35]. The planting density is also changing among golden camellias and planting methods. If growing on bared land, density 3,300-5,000 trees/ha can be used [35]. While it is around 500 trees/ha by growing under forest canopy [35, 37-38].

Fertilizing plantation of golden camellias is applied one a year in May-July, which supports forming numerous and healthy flower buds. Compost and NPK are usually used. Generally, disease and insect attacks are not usually found in plantations of golden camellias. However, biological control is widely used in blooming season to reduce insects coming to suck flowers, which is said to effect on flower quality. Garlic and union are soaked in alcohol for weeks, the extract is then sprayed on canopy of golden camellias [15]. This is a cheap and environmental method for insect control in golden camellias plantations.

Comment [S14]: Once in a year

Comment [S15]: Which is said to have effect

Comment [S16]: Environmental friendly

4. OPPORTUNITIES AND CHALLENGES FOR FUTURE DEVELOPMENT

Due to high value on human health, the commercial value of golden camellias is much

higher compared to green tea. In Vietnam, one kg dry flowers cost 600-700 US$ and one kg dry leaves cost 40-50US$ in 2018 [15]. While it cost 320 US$/ 1 kg dry flowers in China [39]. It is noted that a tree of *C. euphlebia*, a species with natural distribution in south China and north Vietnam, which is 2.5-3 m tall and 2.2-2.7 m crown diameter, can yield up to 3 kg fresh flowers, equaling to 0.5 kg dry per year [15]. Therefore, growing golden camellias could be potential for poverty reduction to ethnic people in mountainous areas. In Vietnam, harvesting flowers from natural forests is not available recently as all bloomed trees were dug up and transplanted in gardens. The future development of golden camellias is to plant best cultivars other than from individuals dug from natural forests. While, natural populations of golden camellias are still much available in China [31, 39]. It is not much available in Vietnam. Suitable and sustainable management strategies should be considered for natural populations, which first must be preserved in-situ, and then apply suitable techniques to promote blooming and control quality.

To grow any species successfully, studies on mapping suitable planting areas, selecting best cultivars, planting and tending techniques must be carefully researched before recommending for application. There are 52 golden camellias (Table 1) described in China and Vietnam. Each species can grow in limited land areas, it has different flower size (Fig. 1), different active gradients, and healthcare values [21, 25, 27-29]. Therefore, details studies on such aspects must also be conducted before recommending for practical application.

With high price of 320-700US$/ 1 kg dry flowers, it seems that golden camellias are potential tree species for poverty reduction to ethnic people in mountainous areas. However, such high price [15, 39] may result from low productivity recently, because of limited areas. In the future, if areas of golden camellia plantation increase without careful plans, total flower productivity increases exceeding demand. As nature of demand and supply price of flowers will decrease, leading to lower benefit of golden camellia growers. Therefore, a sustainable development plan for golden camellias must be carefully considered. The plan must be developed by collaboration among policy makers, researchers, growers, and marketers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Cao J. Collected species of the genus camellia an illustrated outline. Zhejiang Science and Technology Publishing House. 2005.

2. Chang HT, Ye CX. A revision of the species *Camellia chrysantha* (Hu) Tuyama. Acta Scientiarum Naturalium Universitatis Sunyatseni. 1991;30:63-65

3. Liang SY. The discovery and name of *Camellia nitidissima*. China Plants. 1992;5:7.

4. Ninh T, Hakoda N. Three new species of the genus Camellia from Viet Nam. International Camellia Journal. 1998;30:76–79.

5. Ninh T, Ninh LNH. Diversity of wild camellia species of Tam Dao National Park. Journal of Science – Natural Sciences and Technology. 2007;23:52–154.

6. Hansen WM. The 3rd international academic forum on yellow camellias–a personal view. 2013. pp. 17–19.

7. Dung LV, Anna L, Hanh NT, Lieu NT. *Camellia thuongiana* – A new yellow camellia species from Vietnam. Dalat University Journal of Science. 2016;6:338–344.

8. Le NNH, Uematsu C, Katayama H, Nguyen LT, Tran N, Luong DV, Hoang TS. *Camellia tuyenquangensis* (Theaceae), a new species from Vietnam. Korean Journal of Plant Toxonomy. 2017;47:95–99.

9. Hung TC, Ye L. *Camellia impressinervis* Hung T. Chang & S. Ye Liang. Acta Scientiarum Naturalium Universitatis Sunyatseni. 1979;18:72.

10. Le XT. Initial research on morphological, ecological and growth characteristics of golden camellias in Son Dong-Bac Giang, Vietnam. Master Thesis, Vietnam Forestry University. 1997.

11. Hakoda N, Kirino S, Tran N. New species of genus camellia in Viet Nam. International Camellia Journal. 2007;39:54–57.

12. Ninh T. *Camellia kirinoi* - a new species and precious gene resource should be conserved. Journal Genetics and Applications. 1999;2:37–38.

13. Le TC. Research on ecological characteristics and cutting propagation for *Camellia tienii* Ninh in Tamdao National park. Master Thesis, Vietnam Forestry University. 2012.

14. Do VT. Ecological characteristics of some golden camellias in Tamdao National Park, Vietnam. Journal of Agriculture and Rural Development. 2016;1+2.

15. Tran VD. Overview of golden camellias in Cao Bang. Scientific Report. Silviculture Research Institute. Vietnamese Academy of Forest Sciences. Hanoi, Vietnam. 2018.

16. Ngo QD, Ngo QH, Le SD. Living conditions of *Camellia tonkinensis* in Ba Vi (Ha Tay and Son Dong (Bac Giang), Vietnam. Vietnam Journal of Forest Science. 2008b;4:806–810.

17. Wheeler L, Rivers MC. *Camellia impressinervis*. The IUCN Red List of Threatened Species. 2015.

18. Vogt KA, Vogt DJ, Palmiotto PA, Boon P, Ohara J, Asbjornsen H. Review of root dynamics in forest ecosystems grouped by climate, climatic forest type and species. Plant and Soil. 1996;187:59–219.

19. Guangxi Institute of Botany. Guangxi Flora. Guangxi Science and Technology Press. Nanning. 1991.

20. Wei JB, Li X, Song H, Liang YH, Pan YZ, Ruan JX, Qin X, Chen YX, Nong CL, Su ZH. Characterization and determination of antioxidant components in the leaves of *Camellia chrysantha* (Hu) Tuyama based on composition-activity relationship approach. Journal of Food and Drug Analysis. 2015;23:40–48.

21. Qin XM, Lin HJ, Ning EC, Lu W. Antioxidative properties of extracts from the leaves of *Camellia chrysantha* (Hu) Tuyama. Food Science and Technology. 2008;2:189e91.

22. Pereira CG, Barreira L, Bijttebier S, Pieters L, Neves V, Rodrigues MJ, Rivas R, Varela J, Custodio L. Chemical profiling of infusions and decoctions of *Helichrysum italicumsub sp. picardii* by UHPLC-PDA-MS and in vitro biological activities comparatively with green tea (*Camellia sinensis*) and rooibos tisane (*Aspalathus linearis*). Journal of Pharmaceutical and Biomedical Analysis. 2017;145:295–603.

23. Huang YL, Chen YY, Wen YX, Li DP, Liang RG, Wei X. Effects of the extracts from *Camellia nitidssimas* leaves on blood lipids. Lishizhen Medicine and Materia Medica Research. 2009;4:5.

24. He D, Wang X, Zhang P, Luo X, Li X, Wang L, Li S, Xu S. Evaluation of the anxiolytic and antidepressant activities of the aqueous extract from *Camellia euphlebia* Merr. ex Sealy in Mice. Evidence-Based Complementary and Alternative Medicine. 2015; Article ID 618409.

25. Wan CP, Yu YY, Zhou SR, Cao SW. Antioxidant and free radical scavenging activity of *Camellia nitidissima* Chi. Asian Journal of Chemistry. 2011; 23:2893–2897.

26. Lin JL, Lin HY, Yang NS, Li YH, Lee MR, Chuang CH, Ho CT, Kuo SC, Way TD. Chemical constituents and anticancer activity of yellow camellias against MDA-MB-231 human breast cancer cells. Journal of Agricultural and Food Chemistry. 2013;61:9638–9644.

27. Qi J, Shi R, Yu J, Li Y, Yuan S, Yang J, Hu J, Jia A. Chemical constituents from leaves of *Camellia nitidissima* and their potential cytotoxicity on SGC7901 Cells. Chinese Herbal Medicines. 2016;8:80–84.

28. Yang R, Wang WX, Chen HJ, He ZH, Jia AQ. The inhibition of advanced glycation end-products by five fractions and three main flavonoids from *Camellia nitidissima* Chi flowers. Journal of Food and Drug Analysis. 2018a;26:252–259.

29. Yang R, Guan Y, Zhou J, Sun B, Wang Z, Chen H, He1 Z, Jia A. Phytochemicals from *Camellia nitidissima* Chi flowers reduce the pyocyanin production and motility of pseudomonas aeruginosa PAO1. Frontiers in Microbiology. 2018b;8:article 264.

30. Parsek MR, Greenberg EP. Acyl-homoserine lactone quorum sensing in gram-negative bacteria: a signaling mechanism involved in associations with higher organisms. Proceedings of the National Academy of Sciences of the United States of America. 2000;97:8789–8793.

31. Hung C, Lee S. The conservation and cultivation of yellow *Camellia* Species. The Third International Academic Forum on Yellow Camellias. 2013; pp. 79–82.

32. Duong DT. Research on morphological, ecological and growth characteristics, and cutting propagation for *Camellia tamdaoensis* Ninh et Hakoda. Master Thesis, Vietnam Forestry University. 2011.

33. Ngo TMD. Research on selecting species, province, and propagating golden camellias for preservation and development. Scientific Report. Vietnamese Academy of Forest Sciences. 2012.

34. Ngo QD, Le TS, Dinh TL. Result on cutting propagation for *Camellia tonkinensis* and *Camellia euphlebia*. Vietnam Journal of Forest Science. 2008a;3:704–709.

35. Thach DV. Research and development of genetic sources of golden camellias *Camellia tamdaoensis* and *Camellia petelotii* in Tamdao National park. Scientific Report. 2017.

36. Cuong LT. Research on ecological characteristics and cutting propagation for *Camellia tienii* Ninh in Tamdao National park. Master Thesis. Vietnam Forestry University. 2012.

37. Qian W. World's only golden camellia gene bank set up in Guangxi. http://www.china.org.cn/english/scitech/38705.htm. 2002. Accessed on 7.1.2019.

38. Gaoke Z. China golden camellias. http://chinagoldencamellia.com/display.html. 2017. Accessed on 7.1.2019.

39. Patricia S. Overview. The Third International Academic Forum on Yellow Camellias. 2013; pp. 11–13.

278 **Table 1. List of 52 golden camellias**

No.	Scientific name	No.	Scientific name
1	*Camellia achrysantha* Hung T.Chang & S.Ye Liang	27	*Camellia longruiensis* S. Y. Liang & X. J. Dong
2	*Camellia aurea* H.T. Chang	18	*Camellia longzhouensis* J.Y.Luo
3	*Camellia chrysantha* (Hu) Tuyama	29	*Camellia megasepala* Hung T.Chang & Trin Ninh
4	*Camellia chrysanthoides* H.T.Chang *(C. xiashiensi; C. longzhouensis)*	30	*Camellia micrantha* S. Ye Liang & Y. C. Zhong
5	*Camellia crassiphylla* Ninh & Hakoda	31	*Camellia multipetala* S. Ye Liang & C. Z. Deng
6	*Camellia cucphuongensis* Ninh & Rosmann	32	*Camellia murauchii* Ninh & Hakoda
7	*Camellia dalatensis* Luong, Tran & Hakoda	33	*Camellia nitidissima* C.W.Chi
8	*Camellia dilinhensis* Ninh & V.D.Luong	34	*Camellia nitidissima var. phaeopubisperma* S. Ye Liang & Z. H. Tang
9	*Camellia dormoyana* (Pierre) Sealy	35	*Camellia parvifolia* Makino
10	*Camellia euphlebia* Merr. ex Sealy	36	*Camellia parvipetala* J. Y. Liang & Z. M. Su
11	*Camellia fascicularis* Hung T.Chang	37	*Camellia petelotii* (Merr.) Sealy
12	*Camellia flava* (Pit.) Sealy	38	*Camellia phanii* Hakoda et Ninh
13	*Camellia gilbertii* (A.Chev.) Sealy	39	*Camellia pingguoensis* D. Fang *var. terminalis* (Liang et Su) S. Y. Lang
14	*Camellia grandis* (C.F.Liang & S.L.Mo) H.T.Chang & S.Ye Liang *(C. ptilosperma)*	40	*Camellia pingguoensis* D. Fang
15	*Camellia hakodae* M.Sealy	41	*Camellia pubipetala* Y. Wan & S. Z. Huang
16	*Camellia hamyenensis* M.Sealy	42	*Camellia quephongensis* Hakoda et Ninh
17	*Camellia hirsuta* Hakoda et Ninh	43	*Camellia quinqueloculosa* S.L.Mo & Y.C.Zhong
18	*Camellia huana* T. L. Ming & W. J. Zhang *(C. liberofilamenta)*	44	*Camellia rosmannii* Ninh
19	*Camellia huulungensis* Rosmann & Ninh	45	*Camellia tamdaoensis* Ninh et Hakoda
20	*Camellia impressinervis* Hung T. Chang & S. Ye Liang	46	*Camellia terminalis* J.Y.Liang & Z.M.Su
21	*Camellia indochinensis* Merrill	47	*Camellia thanxaensa* Hakoda et Kirino
22	*Camellia indochinensis var. tunghinensis* (Hung T. Chang) T. L. Ming & W. J. Zhang *(C. tunghinensis)*	48	*Camellia tianeensis* S.Y.Liang & Y.T.Luo
23	*Camellia kirinoi* Ninh	49	*Camellia tienii* Ninh
24	*Camellia leptopetala* Chang & S.Y.Liang	50	*Camellia tonkinensis* (Pit.) Cohen-Stuart
25	*Camellia limonia* C.F.Liang & S.L.Mo (*C. limonia f. obovata* S.L.Mo & Y.C.Zhong)	51	*Camellia vuquangensis* Luong, Tran & L. T. Nguyen
26	*Camellia flavida* H.T.Chang	52	*Camellia flavida var. patens* (S.L.Mo & Y.C.Zhong) T.L.Ming

Fig. 1: ***Camellia tuyenquangensis*** **(above left),** ***C. impressinervis*** **(above middle),** ***C. kirinoi*** **(above right),** ***C. megasepala*** **(below left),** ***C. hamyenensis*** **(below middle), and** ***C. tienii*** **(below right)**

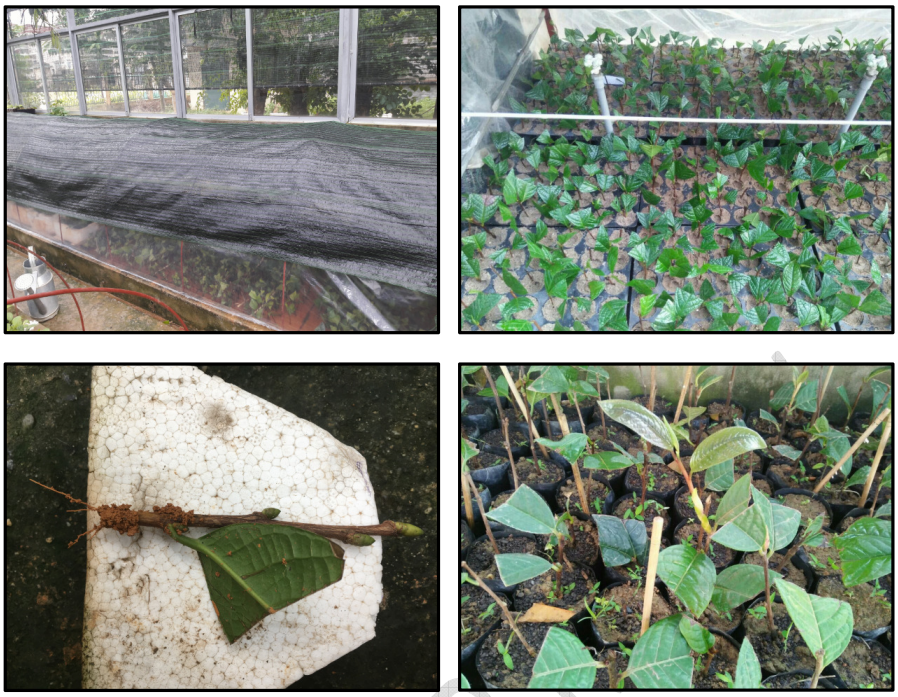

Fig. 2: Cutting propagation for *C. impressinervis*. Shading bed 50-75% (above left), automatic spraying system (above right), rooted cutting (below left), and seedlings (below right)