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REVIEW ARTICLE

Bletilla striata: a review of seedling propagation and cultivation modes

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Abstract In recent years, the domestic and international market demand for *Bletilla striata* has increased rapidly because of its wide use in medical, pharmaceutical, chemical, health, cosmetology, and other fields. The increased demand and a shortage of wild herbal resources have led to the development of large-scale introduction and cultivation programs. Using our research results and the relevant literature, this paper characterizes the original *B. striata* plant, as well as seedling propagation techniques and its main cultivation modes, and discusses some problems in the *B. striata* production process. This work will provide a reference for industry development and the promotion of *B. striata*.

Keywords *Bletilla striata* · Medicinal uses · The original plant · Seedling propagation · Cultivation modes

Introduction

Bletilla striata (Thunb.) Reichb. f. (Orchidaceae) is a herbaceous perennial plant (Chinese Academy of Sciences "Chinese Flora" Editorial Board 1999). The dried tuber of *B. striata* is a traditional Chinese herbal medicine and has been widely used for thousands of years to treat hemoptysis, hematemesis, trauma and bleeding, ulcers and swelling, pain, burns, and skin chapping. Modern pharmacological research has so far isolated ~ 125 compounds from *B. striata,* including bibenzyls (Feng et al. 2010; Li et al. 1993; Takagi et al. 1983; Yamaki et al. 1991), dihydrophenanthrenes, biphenanthrenes, phenanthrenes (Bai et al. 1990; Feng et al. 2010; Li et al. 1991; Morita et al. 2005; Yamaki et al. 1989, 1990, 1993a, b), triterpenoids and their saponins, steroids and their saponins, cyanidin glycosides, phenanthraquinones, anthraquinones, lignans, organic acids, and glucosyloxybenzyl 2-isobutylmalates (He et al. 2017). Additionally, *B. striata* is rich in polysaccharides. With hemostasis, anti-tumor (Zhan et al. 2014), anti-bacterial, anti-inflammatory (Diao et al. 2008), wound-healing promotion (Luo et al. 2010), cell growth promotion, anti-angiogenesis (Liu et al. 2008), anti-hepatic fibrosis (Wang et al. 2014), immune regulation (Peng et al. 2014), and other pharmacological effects, *B. striata* can significantly reduce tumors and oxidative damage, as well as promote antimicrobial wound healing. In addition to its wide application as a Chinese herbal remedy, *B. striata* has been made into a variety of Chinese traditional patent medicines, such as Bai Ji granules, Bai Ji syrup, and Yunnan Baiyao, for the treatment of clinical diseases (Zhang et al. 2012). Since *B. striata* seeds have no endosperm, they lack a supply of nutrients during germination and require symbiotic fungi under natural conditions. Thus, the *B. striata* reproduction rate is extremely low and this coupled with over-exploitation has made wild resources scarce (Li et al. 2012). *Bletilla striata* is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora and is under the second-class protection of the national wild plant conservation list in China (the second batch). Recently, with the increasing demand for *B. striata*,

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the market gap between supply and demand has increased yearly and is now very prominent. Therefore, the scale of cultivation of *B. striata* has expanded rapidly. In this paper, based on a review of relevant literature and field investigations of domestic *B. striata* production enterprises, we provide a reference for promoting the effective preservation of *B. striata* germplasm resources, achieving sustainable utilization of wild *B. striata*, and resolving the shortage in *B. striata* resources.

The original plant

The genus *Bletilla* consists of about six species worldwide, which are mainly distributed in China, North Korea, Japan and Burma (Li et al. 1993). There are four species in China, namely *B. striata*, *B. formosana* (Hayata) Schltr, *B. ochracea* Schltr, and *B. sinensis* (Rolfe) Schltr (Table 1). At present, only *B. striata* is recorded in the Chinese Pharmacopoeia as a medicinal plant (Zhao et al. 2013). *Bletilla striata* was first mentioned in Shennong's Classic of Materia Medica, and is also recorded in the main ancient Chinese herbal literature (Sun et al. 2010). However, there is a phenomenon of mixed cultivation of *B. formosana*, *B. ochracea* and *B. striata*, which leads to confusion of provenances and affecting *B. striata* medicinal effectiveness and safety. Therefore, identifying the morphological differences among the four species of genus *Bletilla* helps to ensure the reliability of *B. striata* provenance.

Techniques for seedling reproduction

The *B. striata* capsule is cylindrical, with six longitudinal edges, and contains a large number of seeds. The seeds are mature at the proembryo stage. The mature seeds are very small, and the seed shell consists of one row of transparent dead cells. The embryo remains at the proembryo stage, and has the following characteristics: undifferentiated mature embryo, degraded suspensor and exalbuminous (Li et al. 2012). The natural reproduction rate of *B. striata* is low, and traditional asexual reproduction methods are time-consuming, have a low propagation efficiency, and are difficult to perform on a large scale (He et al. 2008; Jingchao et al. 2013). At present, the seedling propagation techniques for *B. striata* are mainly tuber reproduction, direct seed sowing, aseptic seed culture, plant division-based propagation, rapid propagation in vitro and artificial seeding (Fig. 1).

Tuber reproduction

As *B. striata* seeds germination is difficult, traditional cultivation mainly relies on tuber propagation, in which a pseudobulb with a bud is directly planted as a seed stem. Tuber propagation is generally used for the artificial domestication of wild *B. striata* and small-scale cultivation. *B. striata* is generally collected from October to November, and 1-year-old pseudobulbs with old stems and buds, of similar size, with many bud eyes, no diseases or insect pests, and without damage are selected as planting materials. The pseudobulbs are divided into small pieces, each of which has at least 1–2 buds. When the incisions are dry or after they are dipped in plant ash, the pieces are planted carefully to try not to damage the pseudobulb epidermis and buds. *Bletilla striata* is a shallow-rooted medicinal plant, and is best planted in sandy loam with a thick soil layer that is fertile, loose, well-drained, and rich in humus. The planting density is 20 cm × 30 cm, and the depth is 8–10 cm; pseudobulb pieces are placed with the buds upward, covered with soil, and given adequate water (Yunnan academy of agricultural sciences institute of flowers 2015). This method is simple, convenient, and easy to perform. The disadvantages are the low propagation coefficient and the long time required to accumulate a large number of seedlings, making it unsuitable for large-scale planting (Ren et al. 2016).

Direct seed sowing

Orchidaceae seed structure is simplified and endosperm-free. However, the parenchymal cells of the embryo of *B. striata* seeds store large amounts of protein, fat and carbohydrates, which can be used as nutrients for seed germination like endosperm. Thus, *B. striata* seeds germination capacity is better than other orchids under conventional conditions (Guo and Xu 1990). The seedling substrate should consist of bark powder, humus, nutrient soil, fowl dung and peat soil in a volume ratio of 15:20:8:1:5, and seedlings should be grown at an air temperature 20–35 °C and a relative humidity of 60–80%. Spraying the seeds with different nutrient solutions periodically at different stages of seed germination can increase the seed germination rate from 5% to 69.7% ± 3.13% under natural conditions. The diameter of the pseudobulb is generally 1–1.5 cm at 180 days after sowing (DAS) (Niu and Wang 2016).

The storage duration of *B. striata* seeds is negatively correlated with the germination rate and growth. Using mature seeds stored for a short time as a seed source is recommended for the production of *B. striata* seedlings (Yang et al. 2016). The germination rate of wild *B. striata* seeds was found to be 35.2% after treatment with ethylene, which was 13.6% and 19.8% higher than with a warm water (50 °C) treatment and at normal temperature, respectively (Huang 2013).

Table 1 Morphological comparison of the four species of *Bletilla* in China. *Source* Flora of China (1999)

Species	Leaf	Pseudobulb	Flower	Elevation (m)	Geographical distribution	Application
B. striata	4–6 leaves, usually broad; narrowly oblong or lanceolate; apex is acuminate; basal part is narrowly sheathing and clasping	Oblate, above with the ring like water chestnuts, rich in viscosity	Inflorescences with 3–10 flowers; inflorescence axis is tortuous; flowers are large and purplish red or pink, rarely white; sepals and petals are about 25–30 mm long; labellum 3-lobed; 5 lamellae on the lip; lamellae are wavy. Flowering from April to May	100–3200	The south of Shanxi, the southeast of Gansu, Jiangsu, Anhui, Zhejiang, Jiangxi, Fujian, Hubei, Hunan, Guangdong, Guangxi, Sichuan, Guizhou. The Korean Peninsula and Japan	Chinese Pharmacopoeia
B. formosana	3–5 leaves, narrow; The length and width of leaves varied greatly	Oblate ovoid, above with the ring like water chestnuts, and rich in viscosity	Raceme with 2–6 flowers; inflorescence axis is tortuous; flowers are small and lavender or pink, rarely white; sepals and petals are about 15–21 mm long; labellum 3-lobed; 5 lamellae on the lip; lamellae are wavy. Flowering from April to May or June	600–3100	The south of Shanxi, the southeast of Gansu, Jiangsi, Guangxi, Sichuan, Guizhou, the central to northwest of Yunnan, the southeast of Tibet (Zayu), Taiwan. Japan (Ryukyu)	Sichuan, Guizhou and Chongqing
B. ochracea	4 leaves, oblong lanceolate	Oblate ovoidor or irregularly shaped, above with the ring like water chestnuts, rich in viscosity	Inflorescences with 3–10 flowers; inflorescence axis is tortuous; flowers are medium large; sepals and petals are yellowish white, or yellowish green on its back, yellowish white on the internal surface, rarely white; labellum 3-lobed; 5 lamellae on the lip; lamellae are wavy. Flowering from May to June	300–2350	The south of Shanxi, the southeast of Gansu, Henan, Hubei, Hunan, Guangxi, Sichuan, Guizhou, Yunnan	Yunnan, Sichuan and Shanxi
B. sinensis	2–3 leaves, lanceolate or elliptic-lanceolate, exist as basal leaves	Subglobose	Inflorescences with 3–10 flowers; flowers are small and lavender; the labellumis unlobed or not distinct 3-lobed; 3 lamellae on the lip; lamellae with a fringe of serration or tassels. Florescence is in June	–	Yunnan (mengzi county), Thailand	Less application

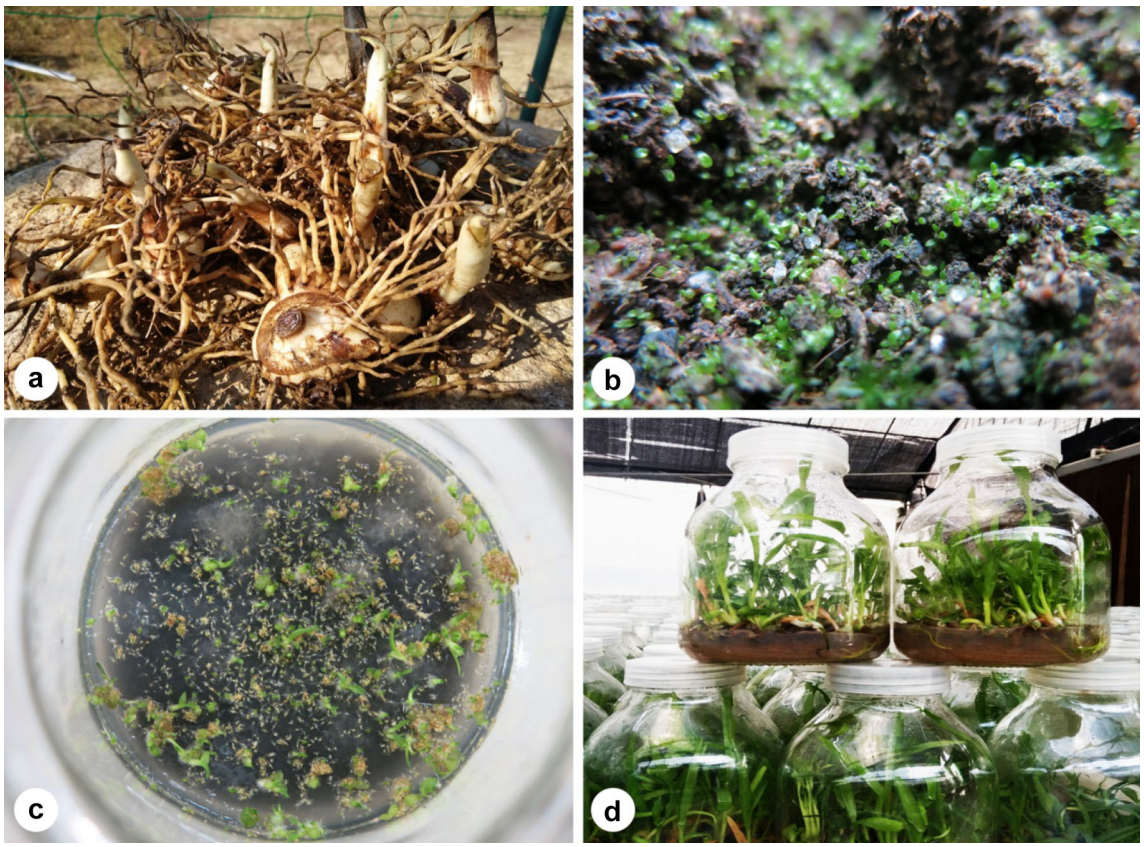

Fig. 1 Techniques for seedling reproduction of *B. striata*. **a** Tuber reproduction. **b** Directly sowing seed. **c** Aseptic seed culture. **d** Training plantlet

Aseptic seed culture

Seed sterile culture is a kind of tissue culture technique. Using explants from seeds for the rapid propagation of *B. striata* has the following advantages: first, the number of *B. striata* seeds is large compared with the limited number of green tubers, as each capsule contains about 100,000 small seeds; second, the seeds are easy to store and convenient to use; third, the capsules are easy to disinfect and the contamination rate is low; and fourth, the cultured seeds sprout fast and grow rapidly, and the seedlings are robust. In general, tissue culture of *B. striata* using seeds as explants offers a shortcut to rapid propagation (Wei et al. 2008).

Bletilla striata seeds for aseptic culture are generally collected from uncured mature capsules, and washed with tap water to remove sand and dust. After washing, they are soaked in water for 20 min, washed repeatedly with tap water, cleaned in reverse osmosis water and placed on a sterile bench. The disinfection steps are as follows: soak in 75% ethanol for 1 min, rinse twice in sterile water, soak in NaClO solution (available chlorine $\geq$ 5%) for 10 min, wash five times with sterile water, dry the surface moisture using sterile filter paper, longitudinally cut with a scalpel, and spread the seeds evenly on the prepared germination medium (Nie et al. 2016). The tissue culture processes used after the seeds germinate and form protocorms, differ. Researchers mainly use the following tissue culture program: "protocorms → induction of protocorm proliferation → induction of shoot differentiation → root induction", in which proliferation occurs mainly through the induction of protocorm proliferation. However, other methods for subculture of protocorms are also used, such as "protocorms → induction of multiple shoot proliferation → induction of shoot differentiation → root induction", which uses multiple shoots, or "protocorms → induction of shoot differentiation → root induction" and "growth and differentiation → root induction", which have no proliferation or subculture steps (Guan et al. 2010). Although *B. striata* seeds are numerous, the cultivation program involving directly inducing protocorm differentiation into seedlings is generally selected to make the cultivation process easier and reduce the cost (Ren et al. 2016). The development of *B. striata* has four stages: embryo, protocorm, rhizome, and pseudobulb. After imbibition, *B. striata* seeds differentiate green buds opposite the suspensor end. The buds develop into cotyledons,

and the embryo breaks the seed coat to form a protocorm. Groups of white villous rhizoids form opposite the cotyledons. The development of the meristem tip of protocorms follows the tunica-corpus theory. With the internal differentiation of multiple vascular bundles, *B. striata* transitions from the protocorm to the rhizome stage. Root primordium development begins with the rhizome vascular bundle. As the rhizomes gradually expand, the internal ground meristem differentiates into mature parenchyma, and a pseudobulb begins to form (Nie et al. 2016). The effects of basic culture medium type, light cycle, and sterilant, sucrose, and activated carbon concentrations on the seed germination of *B. striata* were investigated using MS medium as the basic medium. The optimum conditions for the germination of *B. striata* were 1/2 MS medium as the basic medium, with 1% NaClO, 2% sucrose, and 0.1% activated carbon, and a 10–15 h/days photoperiod, which resulted in a germination rate $\geq$ 80% (Su-Qin 2010). The germination rate was positively correlated with embryo age and the embryo rate of seeds, whereas the germination time was negatively correlated with these factors. For seeds with 16-week-old embryos, the germination rate reached 84% on medium supplemented with 1 g/L Huabao-1 and 2 g/L Huabao-2. The germination rate of seeds with 20-week-old and older embryos was not affected by the culture medium and reached 100%. Moreover, the germination time was only 7 days. The best culture medium for the multiplication of cluster shoots was 1/2 MS + 4.0 mg/L 6-benzylaminopurine (6-BA) + 0.2 mg/L 1-naphthaleneacetic acid (NAA) + 100 g/L coconut milk, on which the multiplication rate was 4.41. Medium with 1/2 MS + 0.2 mg/L NAA was favorable for root growth, and the rooting rate was 90% (Fu et al. 2006). Cryopreservation and preservation under normal temperature conditions are not effective for fresh capsules of *B. striata*. The best storage temperature for fresh capsules is 5 °C. After 60 days storage, the seed germination rate begins to decline slowly, and is $\sim$ 50% after 5 months of storage. Cryopreservation has almost no effect on the longevity of dry seeds (Zhao et al. 2007).

Rapid propagation in vitro

In addition to aseptic seeds, *B. striata* tubers, lateral buds, stem tips, roots, or other vegetative organs or tissues can be used as explants in tissue culture systems to obtain tissue culture seedlings. Proliferating buds can be successfully induced by stem tips and lateral buds (Yu et al. 2005). Pseudobulbs, leaves, and roots of *B. striata* have also been used as explants. Pseudobulbs easily formed callus, with an induction rate of 83.3%. The induction rate from roots was 23.3%, but the calli induced were white and loose, and the differentiation rate in subsequent culture was low. Leaves could form callus only on a specific medium, and the induction rate was only 3.3%. Thus, the optimal explants are pseudobulbs of *B. striata*, and roots and leaves are not suitable as callus-inducing explants (Shi et al. 2013). Lei Xiang and others who used young leaves of *B. striata* as explants for tissue culture could not induce calli (Lei et al. 2014).

Many factors affect the rapid in vitro propagation of *B. striata*, such as the choice of explant, the basic culture medium, and the different concentrations and combinations of growth regulators and organic additives. The tissue culture and rapid propagation of *B. striata* were studied on MS medium. Lateral buds and tubers of *B. striata* were used as explants and sterilized with 0.2% $HgCl_2$ for different times to select suitable explants and sterilization times. The basic MS medium or 1/2 MS medium was used with different concentrations of 6-BA or NAA to induce and multiply cluster buds and roots in cultures of *B. striata*. Lateral buds of *B. striata* were suitable explants, and the best sterilization effect was produced by 0.2% $HgCl_2$ for 8 min. MS medium + 1.5 mg/L 6-BA + 0.1 mg/L NAA showed good induction of cluster buds from lateral bud explants. The best multiplication medium for cluster buds was MS + 2.0 mg/L 6-BA + 0.2 mg/L NAA, which produced a multiplication coefficient of 5.0 every 30 days. The best medium for the induction of roots was found to be 1/2 MS + 1.0 mg/L NAA + 0.1 mg/L 6-BA, which produced a rooting rate of 83.3% (Shi et al. 2009). Different hormone combinations affect the induction, proliferation and differentiation of *B. striata* callus. The callus induction rate was highest (89.89%) when 6-BA and 2,4-dichlorophenoxyacetic acid (2,4-D) were added to the MS. 2,4-D is a key growth regulator of *B. striata*. Adding only 6-BA did not induce callus formation, but the addition of both 2,4-D and 6-BA promoted callus induction. Additionally, the callus-induction rate increased as the 2,4-D concentration increased, but the quality of the calli decreased. The addition of NAA and thidiazuron (TDZ) to the differentiation medium promoted callus differentiation in *B. striata*. The differentiation rate increased as the NAA concentration increased, and the differentiation effect of NAA was better than that of TDZ (Xu et al. 2016). Adding indole-3-butytric acid (IBA), banana slurry, or tomato juice could induce effective rooting of *B. striata*. The addition of activated carbon or gibberellic acid (GA_3) to the rooting medium may also be beneficial for root growth and seedling viability, while peptone has an inhibitory effect on rooting. Various additives can affect the total phenol content distribution in *B. striata* tissue culture seedlings, which influences proliferation and differentiation, as well as rooting and other phenomena (Cui et al. 2016).

Artificial seeds

Although tissue culture, to a certain extent, can solve the problem of rapid propagation of *B. striata* seedlings, the tissue culture-based seedling production cycle is long and costly, and the transplant domestication process is also lengthy. Artificial seed technology is a new way to propagate seedlings of *B. striata*. *B. striata* seeds can be embedded in a shell containing nutrients, which also provide a protective function. *Bletilla striata* artificial seeds were manufactured by instillation and taking germinated *B. striata* seeds as an embedding material. The effects of artificial endosperm components, the artificial seed coat matrix, storage conditions and the germination matrix on artificial seed germination and seedling rates were studied. The highest growth and seedling rates were produced with an artificial seed coat matrix of 4.0% sodium alginate + 0.2 mol L^{-1} $CaCl_2$ + 0.4 mg L^{-1} penicillin + 0.3% carbendazim powder + 0.2% sodium benzoate, and MS + 1.0 mg L^{-1} NAA + 2.0 mg L^{-1} kinetin (KT) as artificial endosperm components. Artificial seeds stored at 4 °C for a long time maintained high viability (Li et al. 2012). Artificial seeds made from *B. striata* are small in size, fast to produce, easy to transport and store, and can be successfully sowed in an artificial environment. However, before artificial seeds can be used in the commercial market, the preparation costs need to be lowered and the embedding material formula and other parameters need to be optimized.

Cultivation modes

To protect wild *B. striata* resources and meet market demand, in recent years, many provinces in China, including traditional and non-traditional *B. striata*-producing areas, have been vigorously carrying out cultivation of wild *B. striata*. This includes the development of intensive greenhouse cultivation processes, interplanting cultivation, imitation wild cultivation and potted cultivation modes (Fig. 2). As *B. striata* requires strict environmental conditions during its growth and development, creating an artificial environment suitable for plant growth is the key to successful greenhouse cultivation.

Fig. 2 Different cultivation modes of *B. striata*. **a** Greenhouse intensive cultivation. **b** Potting cultivation. **c** Imitation wild cultivation under *Phyllostachys pubescens* Forests. **d** Intercropping under fig trees

Intensive greenhouse cultivation

Intensive greenhouse cultivation is a facility cultivation mode. Facility cultivation refers to creating artificially controlled environmental conditions that allow plants to grow and develop normally, without adverse environmental effects on production, to ensure stable production and access to high-yield, high-quality agricultural products (Wang et al. 2012b). According to the Good Agricultural Practice for Chinese Crude Drugs guidelines, the cultivation base should be land with good ecological conditions, clean water, good drainage, and open ground, and be well-ventilated. It is also required that the site has no industrial waste within 5 km and is contaminant-free with no garbage or other sources of pollution, and that main roads are 500 m outside the production area. *Bletilla striata*-containing greenhouses can be divided into two categories, simple greenhouses and steel tube canopies.

Bletilla striata tissue-cultured seedlings are generally adapted for $\sim$ 15 days. They are then rinsed with water at the base to remove the planting medium, and soaked in 1000 $\times$ carbendazim before transplanting. The transplant season is spring, when temperature gradually increases. This helps the transplants to adapt to the natural environment (Meng 1996). Transplanting should be shallow and the tubers should be just covered without compressing the soil. The effects of different transplanting conditions on the growth of *B. striata* are varied. A slow transition is required for light and temperature training to avoid excessive injury to the seedlings. A moderate light intensity (6000 lx) is beneficial to seed survival, while low (3000 lx) and high (9000 lx) light intensities are not conducive to seedling survival. Planting plots should be located at an altitude of 600–1500 m in warm and humid areas, with loose fertile, rich humus and well-drained sandy loam soil (Fang et al. 2011). Low-altitude plots should be partially or entirely shaded, while high-altitude plots should be exposed to the sun (Chen et al. 2013). The main diseases of *B. striata* are caused by nigrities artis and root rot. Nigrities artis is treated by 1000 times the liquid control of 70% thiophanate methyl WP. Anthrax is treated by 800 times the liquid control of thiram, and then, the old and sick leaves are removed. Root rot occurs in spring and summer rainy seasons, and it can be prevented by good drainage and waterproofing. The main pest of *B. striata* is the black cutworm, whose larvae bite or chew *B. striata* seedlings and shoots, affecting plant growth. The pest is treated using 90% crystal trichlorfon as bait to trap larvae, and 800 $\times$ 80% trichlorfon WP or 1000 $\times$ 50% phoxim EC to irrigate the roots.

Imitation wild cultivation under forest conditions

Imitation wild cultivation is based on medicinal plant growth and development habits, as well as the requirements of the ecological environment, using forest resources, including appropriate shade trees (Shao et al. 2016). ***Bletilla*** *striata* is a shade plant that is mainly distributed at elevations in the range between 500 and 1500 m. It grows on hillsides, in gullies, near streams and in sparse forests, and prefers humid soil and fertile sandy loam. The canopy density has an effect on the growth of interplanted *B. striata* in *Phyllostachys pubescens* forests, affecting plant height, diameter at ground height, tiller number, tuber diameter and tuber fresh weight, with the most significant effect on tuber fresh weight. The tuber fresh weight varies according to the canopy density. When the canopy density is 0.40–0.59, the tuber fresh weight is the largest, followed by 0.20–0.39 and the smallest with canopy density of more than 0.60. If the forest canopy density is too low, the environment will be too dry; if the forest canopy density is too high, light conditions will be relatively poor. Such conditions are not conducive to the growth of *B. striata* (Luo 2016). The light environment in the forest can be regulated by measures such as moderately thinning trees and removing weeds under the forest. For imitation wild cultivation in a forest, it is better to select a hillside site with relatively flat terrain, a southern or eastern slope of 10°–15°, and convenient water management. In addition, the soil should be fertile and loose, such as well-drained light soil or sandy loam, and the soil thickness is not less than 30 cm. The planting belt ditch should have a width of 20 cm and be 15 cm deep. A base fertilizer of 1500 kg/hm^2 calcium and magnesium should be applied, and then the soil covered and mixed evenly. A grass border of 10 m should be maintained, which is conducive to forest water and soil conservation (Lian 2014).

Pot cultivation

Bletilla striata not only has medicinal value, but also high ornamental value. The flower has a specialized form, in which the stamens and pistils are fused into the column, and the petals are specialized into various shapes including the lip. The flower is mauve and has a long flowering period. The full-bloom stage of a population is $\sim$ 12 days. At the individual level, the flowering duration for each plant is 11–27 d, which is proportional to the number of flowers per plant. *Bletilla striata* is an ideal shade-tolerant flowering plant. Thus, it can be potted as an indoor ornamental (Anders 1992; Schiestl and Schlüter 2009; Wang et al. 2012a).

Flowerpots should be soaked in 5% chlorine disinfectant before planting. Peat soil, pine bark, organic fertilizer,

vermiculite, or river sand can be used in the cultivation substrate, and should be mixed in proportions that not only meet the requirements for water retention, ventilation, and air permeability, but also promote plant fixation. The transplanted seedlings can be domesticated tissue culture seedlings or planted seedlings. Fertilization is mainly based on slow-acting fertilizers. In addition to spraying water, cooling, and humidification, it is necessary to maintain good ventilation and air permeability, otherwise growth is poor and diseases readily occur.

Conclusion and perspectives

Bletilla striata tissue culture has the advantage of being simple and can meet production needs to a large extent, which include providing seedlings for large-scale cultivation. This will help meet the market demand for medicinal *B. striata* resources and can also increase the population numbers, improve the endangered status of *B. striata*, and provide a basis for sustainable use and protection of *B. striata* germplasm resources. At present, large-scale production of *B. striata* mainly uses tissue-cultured seedlings. In recent years, the scale of *B. striata* cultivation has rapidly expanded, and to save money and improve competitiveness, some directly sowed seedlings have been used. However, the growth vigor of these seedlings is weaker than that of tissue culture seedlings, and there is a large mortality rate in the second year after the seedlings are grown. It is possible that directly sowed seedlings are not as strong as tissue culture seedlings, with poor resistance and vulnerability to viral damage. In addition, it is important to determine the optimum active ingredients necessary for *B. striata* production, separation, and purification, as well as collection and utilization, using plant cell culture technology.

Progress has been made in improving cultivation substrates, transplanting methods, fertilizer and water management, pest control, and other key technologies. However, *B. striata* cultivation lacks fine varieties. Differences in the geographical environment, cultivation and management practices can result in great differences in quality. It is difficult to blind introduction or collection of wild resources without knowing the biological characteristics, active ingredient contents, or regional adaptability. Thus, collecting and evaluating germplasm resources of *B. striata*, including breeding fine varieties and determining their active component contents, yield, and adaptability, is an important direction for future research. To control the quality standards of *B. striata*, only morphological and TLC-based (thin-layer chromatography) identifications, as well as control requirements for moisture, total ash and acid-insoluble ash content, were published in the 2005 edition of the Chinese Pharmacopoeia. The 2010 and 2015 editions removed the acid-insoluble ash content, and the 2015 edition added the determination of sulfur dioxide residues. However, quality control of components related to pharmacological activities was not included. To date, most studies have determined the quality of *B. striata* by measuring the polysaccharide content, and the contents of other ingredients have seldom been reported. Consequently, quality and safety evaluation methods for *B. striata* need to be reinforced. These methods should include a combination of quantitative analysis of index components, fingerprints of the main active ingredient group, and heavy metal and pesticide limitation indicators.

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