



Enhancing *Dioscorea persimilis* Yield in Thai Nguyen through Improved Cultivation Technology

Nguyen Minh Tuan ^{a*} and Le Quang Ung ^b

^a Department of Agronomy, Thai Nguyen University of Agriculture & Forestry, Thai Nguyen, Vietnam.

^b Thai Nguyen University of Agriculture & Forestry, Thai Nguyen, Vietnam.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: <https://doi.org/10.9734/ijpss/2025/v37i65488>

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://pr.sdiarticle5.com/review-history/136632>

Original Research Article

Received: 19/03/2025

Accepted: 22/05/2025

Published: 27/05/2025

ABSTRACT

A major challenge in cultivating the plant is its growth habit, as the tubers develop deeply in the soil and extend along the stems, making them difficult to harvest and susceptible to breakage during excavation. The experiment was performed to measure the effect of cultivation technology on growth and yield of Hoai Son medicinal plant *Dioscorea persimilis* at Đình Hóa district, Thai Nguyen province from 2024 to 2025. The experiment was designed in Randomized Complete Block Design with three replications by five treatments (T1, T2, T3, T4, and T5). The germination rate, plant height, stem diameter, leaf size, and tuber yield, were recorded. Results showed that the burlap bag method T4 treatment provided the highest germination rate (98.0%), greatest plant height (204.5 cm), stem diameter, leaf size, and tuber weight (0.68 kg), significantly outperforming the control at the 95% confidence level. These findings suggest that cultivation using burlap bags enhances growth and harvest efficiency of *D. persimilis*, offering a practical approach for improving production in mountainous areas of northern Vietnam.

*Corresponding author: E-mail: nguyenminhtuan@tuaf.edu.vn;

Keywords: *Dioscorea persimilis*; Hoai Son; cultivation technology; yield; Thai Nguyen.

1. INTRODUCTION

Dioscorea persimilis Prain et Burk, commonly known as Hoai Son, belongs to the Dioscoreaceae family and is a valuable medicinal plant widely used in traditional medicine due to its high nutritional and pharmacological value (Mignouna et al., 2003). Hoai Son has the effects of tonifying the spleen, and stabilizing the essence, commonly used to treat digestive disorders, chronic diarrhea, spermatorrhea, and nocturnal urination. The tuber of Hoai Son contains 70-80% starch, along with essential amino acids, B vitamins, and trace elements such as Zn, Fe, Mn; notably diosgenin and saponin bioactive compounds with antioxidant properties, immune-boosting effects, and support for treating chronic diseases such as diabetes (Chang et al., 2013)

In Vietnam, Hoai Son is primarily distributed in the midland and northern mountainous regions such as Thai Nguyen, Bac Kan, Phu Tho, and Yen Bai, where the soil is loose and well-drained, creating favorable conditions for plant growth (Hang et al. 2020). However, the cultivation techniques for Hoai Son are still mostly traditional, with limited mechanization and minimal application of modern technology such as soil tillers, mechanized planters, drip irrigation systems, and tuber harvesting equipment (Ngan et al., 2021). These technologies could be evaluated for their potential to improve efficiency and reduce labor intensity. One of the biggest challenges is the plant's growth characteristics: the tubers grow deeply and along the stems, making them difficult to harvest, prone to breaking during the digging process. This not only leads to yield losses of up to 20–25% due to tuber breakage and incomplete harvesting, but also compromises the quality of the medicinal material, reducing market value by approximately 15%. Additionally, the reliance on manual labor increases production costs by 30–40% compared to mechanized systems, significantly impacting overall economic efficiency. The lack of suitable cultivation technologies leads to inefficient harvesting, directly impacting the yield and commercial value of the crop (Hang et al. 2020).

In Thai Nguyen, despite the large potential for land and favorable climate for developing a medicinal plant zone, Hoai Son production remains fragmented, small-scale, lacking proper planning and specific research on suitable

cultivation techniques for local conditions. Therefore, researching the improvement of Hoai Son cultivation technologies including selecting varieties, planting methods, bed structure, and tuber guiding materials is essential. The goal is to reduce the depth of tuber growth, increase the yield of intact tubers, improve productivity, quality, and economic efficiency.

2. MATERIALS AND METHODS

2.1 Plant Materials and Experiment Treatments

The tuber cuttings, each 5 cm in length, were treated with a mixture of lime and wood ash (at a ratio of 70:30) one week prior to planting. The experiment was conducted in Boocj Nhiêu commune, Định Hóa district, Thai Nguyen province from 2024 to 2025. The experiment consisted of 5 treatments arranged in a Randomized Complete Block Design (RCBD) with 3 replications. Each experimental plot size covered an area of 10 m², with a total experimental area of 150 m², excluding the buffer zone. The experiment included five treatments as follows:

Treatment 1: Cultivation of Hoai Son medicinal plants on a standard soil base (control).

Treatment 2: Cultivation of Hoai Son medicinal plants on raised soil beds of 70 cm.

Treatment 3: Cultivation of Hoai Son medicinal plants in plastic tubes.

Treatment 4: Cultivation of Hoai Son medicinal plants in burlap bags.

Treatment 5: Cultivation of Hoai Son medicinal plants on a plastic sheet base.

Experimental baseline: 9 tons of organic microbial fertilizer + 500 kg of powdered lime + 300 kg of urea (nitrogen) + 500 kg of superphosphate (phosphorus) + 150 kg of potassium chloride per hectare. Nitrogen and potassium fertilizers were applied from April to May, with one-third of the total amount applied each month. The remaining amount was applied in July. Fertilization was carried out in combination with weeding, watering, and soil mounding to support plant growth. Planting density and spacing: 80 cm × 25 cm (50,000 plants per hectare).

The tuber cuttings were placed into different growing media at a depth of approximately 5 cm. After positioning the cuttings, soil was used to cover them, followed by watering and maintaining adequate moisture after planting. After 15–20 days, trellises were constructed to support the plants. It is important to build sturdy trellises, as the vigorous climbing growth of the plants can cause weak structures to collapse.

Plastic tubes with a diameter of 200 mm and length of 1.0-1.2 m, with small drainage holes around the tube. Tubes are placed 60-70 cm deep into the ground, filled with soil, and raised to form a 50-60 cm high bed. Burlap bags of size 90 cm x 120 cm are filled with soil. The bags are placed 40-50 cm deep in the ground and raised to form a 50-60 cm high bed. A layer of plastic sheet is placed 30-40 cm deep into the ground, followed by soil and raised to form a 50-60 cm high bed.

2.2 Data Collection

Germination rate percentage was measured after planting one month by counting the number of seedlings that have sprouted, then calculate the germination percentage. The leaf size (length and width) (cm) was determined with the help of vernier callipers at trellis reach duration. Stem diameter (mm) was measured with the help of digital vernier calipers just above the ground surface 5 cm and the average was calculated at trellis reach duration and harvest duration. The number of tubers per plant was counted and the average was calculated. The tuber size (length and diameter) was determined with the help of Vernier calliper. Tuber weight was measure by weighing and the average was calculated. Yield per treatment was recorded by weighing total number of tubers harvested per plot. The characters of tuber and yield were measured at Harvest duration.

2.3 Statistical Analysis

The data were processed using the SAS 9.1 software to analyze the variability and compare the means between treatments using Duncan's Multiple Range Test at a 95% confidence level.

3. RESULTS AND DISCUSSION

3.1 Effect of Cultivation Technology on Germination Rate of Hoai Son Plants

The results summarize in Fig. 1 shows that the germination rate of the treatments ranged from

95.3% to 98.0%. In which, the highest germination rate was observed in treatment 4 with value of 98.0%, attributed to the better moisture retention and soil aeration characteristics of this method. In contrast, treatment 3 had the lowest germination rate at 95.3%, which could be due to the lower moisture retention capacity of the plastic tubes. Hence, this suggests that planting in burlap bags may enhance the germination rate as compared to other treatments in this experiment. These results are in agreement with former work reported by Marsh et al. (2005). Moreover, the lower germination rate observed in the plastic tube treatment can be explained by the smaller surface area of the tube compared to the burlap bag, which, coupled with the soil medium, has a lower moisture retention capacity, thereby reducing the germination rate. This study did not evaluate the growing medium for plants in plastic tubes. Therefore, further research on suitable growing substrates for tube cultivation is needed to assess the effectiveness of using tubes as a cultivation method.

3.2 Effect of Cultivation Technology on the Morphological Characteristics of Hoai Son Plants

The results presented in Table 1 show that there were significant differences among the treatments in the experiment ($p \leq 0.05$). Treatment 4 exhibited the highest plant height (204.5 cm), followed by treatment 2 at 203.6 cm, both of which were significantly higher than treatment 1 (control) at the 95% confidence level. However, the remaining treatments was not statistically significant difference plant heights as comparison to control treatment ($p < 0.05$). Therefore, this indicates that the different cultivation methods significantly influenced plant height, with the best results achieved using the burlap bag method and high mounds improving plant height grow.

The results summarize in Table 1 also shows that different cultivation techniques had a significant effect on stem diameter at both the time of reaching the trellis and at harvest ($p \leq 0.05$). Treatment 4 had the largest stem diameter at both stages, with values of 3.82 mm at trellis contact and 4.07 mm at harvest, which were significantly higher as comparison to treatment 1 (control) at the 95% confidence level. Treatment 3 had the smallest stem diameter with value of 3.49 mm at the time of reaching the trellis stage and 3.66 mm at harvest, both significantly lower

than the treatment 1 (control). The other treatments had stem diameters similar to treatment 1 at both stages. Leaves play a significant role in plant growth, as the leaf surface is the site for photosynthesis, providing organic matter necessary for plant growth and development. Additionally, leaves are involved in transpiration and gas exchange. A plant with a healthy and full leaf structure has higher photosynthesis efficiency, allowing it to accumulate more nutrients, which contributes to higher yields. Moussa and Salem (2006) showed that photosynthetic intensity, transport efficiency, and overall yield are positively correlated. Leaf development is critical for promoting root growth and the development of other organs, which affects final yield (Huyen and Minh, 2014). As the results of this study showed that there were significant differences between the treatments regarding leaf size ($p \leq 0.05$). The highest leaf length (11.5 cm) was observed in T4 treatment, which were significantly higher than the treatment 1 (control) at the 95% confidence level. Moreover, the remaining treatments were not significantly differences leaf length, except treatment 3 had shorter leaves length as

compared to control treatment (Table 1). For the leaf width, the highest leaf width (7.19 cm) was observed in T4 treatment, while the lowest leaf width (6.50) was found in the control treatment. The other treatments exhibited did not statistically significant differences as comparison to control treatment. Thus, the study demonstrates that different cultivation methods influence leaf size, with planting in burlap bags leading to the largest leaves in both length and width. This result was in agreement with Sunell and Arditti (1983), who observed that the photosynthetic intensity of taro plants increased as the leaf structure developed, reaching its maximum value when the leaves reached their full size.

Therefore, the plant height, stem diameter, and leaf size in treatment 4 provided the best results. This can be explained by the fact that planting in burlap bags promotes stronger root development, which increases water uptake and retention, thereby enhancing plant growth, which leads to greater stem diameter and leaf size. On the other hand, planting in plastic tubes resulted in smaller plant height, stem diameter,

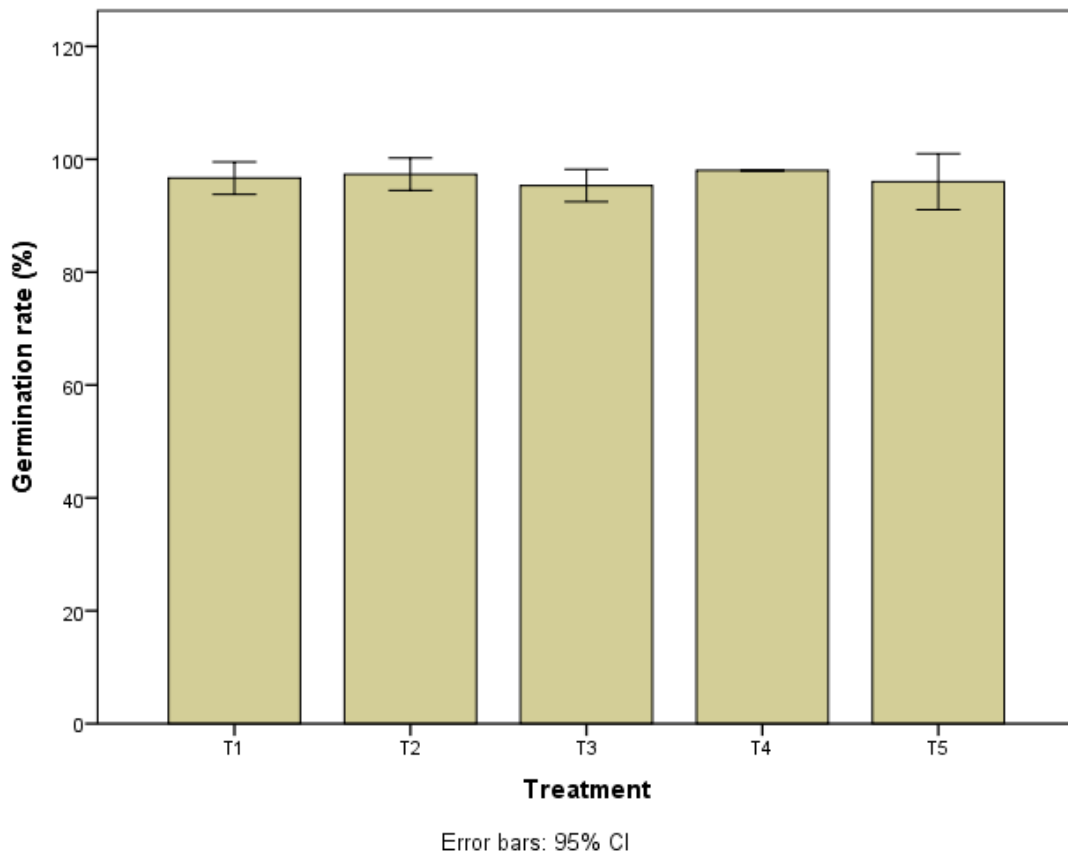


Fig. 1. Effectt of cultivation technology on germination rate of Hoai Søn plants

Table 1. Effect of cultivation technology on morphological characteristics of Hoai Sơn plants

Treatment	Plant height (cm)	Stem Diameter at Trellis reach duration (mm)	Stem Diameter at Harvest (mm)	Leaf length (cm)	Leaf width (cm)
T1 (control)	201.8 ^{b*}	3.68 ^{bc}	3.87 ^{bc}	10.7 ^{bc}	6.50 ^b
T2	203.6 ^a	3.71 ^{ab}	3.93 ^b	11.2 ^{ab}	6.83 ^{ab}
T3	201.7 ^b	3.49 ^d	3.66 ^d	10.5 ^c	6.57 ^b
T4	204.5 ^a	3.82 ^a	4.07 ^a	11.5 ^a	7.19 ^a
T5	201.9 ^b	3.58 ^{cd}	3.75 ^{cd}	10.7 ^{bc}	6.41 ^b
P-value	≤0.05	≤0.05	≤0.05	≤0.05	≤0.05
LSD 0.05	1.11	0.11	0.13	0.63	0.52

Means followed by different letter are significantly different within columns by Duncan's multiple range Test, $p \leq 0.05$

and leaf size due to the limited porosity of the substrate, which constrained plant growth. However, further studies on the substrates and additional nutrients for the growing medium, as well as an evaluation of substrate porosity and moisture retention capacity, are necessary to identify the most suitable medium for plant growth. These findings are consistent with the study by Thuy and Phip (2013).

3.3 Effect of Cultivation Technology on the Yield of Hoai Sơn Plants

The results of the study presented in Table 2 show that there was no significant difference between treatments among tubers number at the 95% confidence level, with each treatment producing 1 tuber per plant. These results were similar to the finding of Hue and Loc (2005). For the tuber weight, the results in Table 2 showed that the highest tuber weight of 0.68 kg was obtained in T4 treatment, followed by T2 treatment with value of (0.66 kg, both significantly higher than the control (treatment 1) at the 95% confidence level. However, the T3 and T5 treatments had the lower tuber weights as comparison to control treatment at the 95% confidence level (Table 2).

As the results presented in Table 2 show that there were significant differences between treatments in terms of tuber length and diameter ($p \leq 0.05$). In term, the T3 treatment has the longest tubers with value of 72.2 cm, followed by treatment 4 and treatment 2 with tubers lengths was 69.1 cm, and 68.6 cm, respectively all significantly longer than control treatment (64.6 cm). However, the shortest tubers (39.5 cm) was observed in T5 treatment and significantly shorter as comparison to control treatment 1. For the tuber diameter, the results in Table 2 showed that the treatment 4 had the largest tuber diameter with value of 4.19 cm, followed by treatment 2 (4.09 cm), both significantly larger than treatment 1 (4.03 cm). Treatment 3 had the smallest tuber diameter (3.74 cm) and significantly smaller as comparison to treatment 1.

The results summarize Table 2 showed that T4 treatment were found to have the highest yield (32.7 tons/ha), followed by treatment 2, both significantly higher than treatment 1 (control). However, treatment 3 and treatment 5 had the lowest yields, with value 26.0 tons/ha, and 25.0 tons/ha, respectively. The high yield in treatment 4 is attributed to the larger tuber weight and diameter, which contributed to higher yields.

Table 2. Effect of cultivation technology on yield of Hoai Sơn plants

Treatment	Number of Tubers (tubers/plant)	Tuber Weight (kg/tuber)	Tuber Length (cm)	Tuber Diameter (cm)	Yield (tons/ha)
T1 (control)	1.0 ^{a*}	0.61 ^b	64.6 ^b	4.03 ^c	30.1 ^b
T2	1.0 ^a	0.66 ^a	68.6 ^a	4.09 ^b	32.0 ^a
T3	1.0 ^a	0.54 ^c	72.2 ^a	3.74 ^d	25.8 ^c
T4	1.0 ^a	0.68 ^a	69.1 ^a	4.19 ^a	32.7 ^a
T5	1.0 ^a	0.52 ^c	39.5 ^c	4.01 ^{bc}	25.0 ^c
P-value	> 0.05	≤ 0.05	≤ 0.05	≤ 0.05	≤ 0.05
LSD 0.05	0.03	0.03	3.65	0.07	1.24

Means followed by different letter are significantly different within columns by Duncan's multiple range Test, $p \leq 0.05$

While treatment 3 had longer tubers compared to treatment 1, its lower tuber weight and diameter resulted in a lower yield. These results are in accordance with the findings of Thuy and Phip (2013), who indicated that larger tuber diameters lead to higher yields in ginger. Treatment 5, which used plastic sheeting, limited tuber development, resulting in significantly smaller tubers and lower yields compared to other treatments.

4. CONCLUSIONS

In conclusion, different cultivation techniques have varying effects on the growth, development, and yield quality of Hoai Sơn plants. Treatment 4 with cultivation in bags, resulted in the best plant growth, development, tuber yield, and tuber quality under production conditions in Thai Nguyen. Therefore, the bag cultivation method is recommended as a practical and effective approach to enhancing vegetative growth and yield of Hoài Sơn in Thai Nguyen province.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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