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Effects of Planting Season on Growth, Development, Yield and Pest Incidence of Indian Ginseng (*Withania somnifera* L.)

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ABSTRACT

Indian ginseng (*Withania somnifera* L.) is a valuable medicinal plant widely recognized for its adaptogenic and pharmacological properties. This study evaluated the effects of different planting seasons on growth, development, yield and pest and disease occurrence of Indian ginseng cultivated in Thanh Tri district, Hanoi. Field experiments were conducted from 2023 to 2025 using a randomized complete block design with five planting seasons (January, March, May, August and November) and three replications. Growth characteristics, yield components and harvested yield were recorded and statistically analyzed. Planting season significantly affected plant survival, vegetative growth and yield. The fresh-to-dry tuber ratio remained relatively stable across planting seasons. Major pests and diseases occurred at low to moderate levels and were effectively managed through integrated pest management practices. The results indicate that Indian ginseng can be cultivated throughout the year under appropriate management conditions. However, planting in August or March is recommended for the Red River Delta region to achieve optimal plant establishment, growth and medicinal yield.

Keywords: *Withania somnifera*, Indian ginseng, Planting season, Medicinal crops, Pest incidence

1. INTRODUCTION

Withania somnifera (L.) Dunal, commonly known as Ashwagandha, Indian ginseng or winter cherry (Mirjalili *et al.*, 2009; Kulkarni & Dhir, 2008) [1, 2], belongs to the family

Solanaceae. The Sanskrit name “Ashwagandha”, meaning “smell of a horse” (Kumar *et al.*, 2008) [3], refers to the characteristic odor of its roots and is associated with the traditional belief that the plant imparts strength and vitality (Piepho *et al.*, 2012) [4]. It has been widely used in traditional medicine for its adaptogenic, anti-stress and immunomodulatory properties (Pandey *et al.*, 2018) [5].

Indian ginseng is a small perennial shrub, typically 60-100 cm in height with extensively branched stems and young plant parts covered by dense stellate hairs (Singh *et al.*, 2010) [6]. Flowering generally begins about 3.5 months after planting, while fruits mature approximately one month later (Prakash *et al.*, 2015) [8]. Previous studies have shown that root yield and the accumulation of bioactive compounds in *Withania somnifera* L. are strongly influenced by environmental and agronomic factors (Verma *et al.*, 2011) [7].

Planting time plays a decisive role in determining crop performance by regulating temperature, rainfall and photoperiod exposure during key growth stages (Sharma *et al.*, 2018) [9]. Previous studies on medicinal plants have shown that inappropriate planting seasons may lead to poor plant establishment (Tripathi *et al.*, 2019) [10], reduced biomass accumulation and lower active compound content (Singh *et al.*, 2020) [11].

Despite increasing interest in cultivating Indian ginseng outside its native range, information on optimal planting seasons under subtropical monsoon conditions remains limited (Kumar *et al.*, 2012) [12]. Therefore, continued research on developing cultivation protocols to refine and accurately determine appropriate agronomic techniques for this medicinal plant is essential in order to expand large-scale production (Choudhary *et al.*, 2016) [13].

2. MATERIALS AND METHODS

2. 1. Plant materials

The research material consisted of Indian ginseng (*Withania somnifera* L.) seeds preserved at the Hanoi Center for Research on Cultivation and Processing of Medicinal Plants, National Institute of Medical Materials.

✓ Seed characteristics:

Seeds were flattened, round, yellow in color, measuring approximately 2×1.5 mm.

Purity: impurities not exceeding 2% (mainly shriveled or empty seeds).

Seed moisture content: <12%. Thousand-seed weight: >1.3 g. Germination rate: >80%.

Free from viral, bacterial, fungal and insect contamination.

✓ Seedlings were propagated from seeds. Healthy seedlings exhibited vigorous growth with a strong root system consisting of 4-8 roots. Average seedling height ranged from 10-15 cm, with 4-6 leaves per plant. Leaves were healthy, green, uniform in size and shape and no pests and diseases.

Research materials included Song Gianh bio-organic fertilizer with the following composition: moisture 30%, organic matter 15%, P_2O_5 1.5%, humic acid 2.5%, Neutral (Ca, Mg, S), beneficial microorganisms (3×10^6 CFU/g), supplemented with 25 kg N, 20 kg K_2O , urea, superphosphate, and potassium chloride.



Figure 1. Indian ginseng seeds.



Figure 2. Indian ginseng seedlings.

2. 2. Study site

The experiment was conducted in Thanh Tri, Hanoi, Vietnam.

2. 3. Study period

The study was carried out from March 2023 to June 2025.

2. 4. Research contents

- Evaluation of the effects of planting season on survival rate and growth duration of Indian ginseng;
- Assessment of the effects of planting season on selected growth and development parameters;
- Determination of the effects of planting season on yield and quality of Indian ginseng medicinal materials;
- Monitoring pest and disease incidence affecting plant growth and yield components.

2. 5. Research methods

Field experiments were arranged according to Nguyen Thi Lan & Pham Tien Dung (2006), a widely accepted experimental approach in agronomic field trials to minimize environmental variability (Montgomery, 2017) [14]. Growth, yield and morphological parameters were recorded using standardized measurement protocols commonly applied in medicinal plant research (Chattha *et al.*, 2013) [15]. The study evaluated the effects of planting season on growth, development and yield of Indian ginseng.

Experimental period: January 2023 to December 2024

Five planting seasons were tested:

PS1: January 5

PS2: March 5

PS3: May 5

PS4: August 5

PS5: November 5

Experimental design:

Seedlings were raised 90 days prior to each planting season. The experiment followed a randomized complete block design (RCBD) with one factor, five treatments, and three replications. Each plot covered 20 m², giving a total experimental area of 300 m² (excluding guard rows). Plant spacing was 30 × 60 cm. Fertilizer application per hectare included 3 tons of Song Gianh bio-organic fertilizer, 25 kg N, 25 kg P₂O₅ and 20 kg K₂O.

- Methods for studying insect pests

The survey method for detecting insect pests was conducted in accordance with the "Methodology for Basic Surveys of Agricultural Pests and Their Natural Enemies" (Plant Protection Research Institute, 1997).

2. 6. Observed parameters

2. 6. 1. Growth and development duration:

Germination time: From sowing to the time when 50% of the plants per plot have emerged with two cotyledon leaves.

- Germination rate: Percentage of seed germination in different experimental treatments under laboratory and field conditions (%).
- Time from sowing/planting to the appearance of true leaves (days): Calculated from the sowing/planting date to the time when 50% of the plants develop true leaves.
- Time from sowing/planting to flowering (days): Calculated from the sowing/planting date to the time when 50% of the plants are in bloom.
- Time from sowing/planting to fruit set (days): Calculated from the sowing/planting date to the time when 50% of the plants set fruit.
- Time from sowing/planting to fruit maturity (days): Calculated from the sowing/planting date to the time when 85% of the fruits are mature.
- Time from sowing/planting to root/tuber harvest (days): Calculated from the sowing/planting date to the harvest of roots/tubers.

2. 6. 2. Growth parameters

- Plant height (cm): Measured from the ground surface to the tip of the highest leaf.
- Number of branches (branches/plant): Total number of branches per plant.
- Number of primary branches per plant: Total number of first-order branches per plant.

2. 6. 3. Seed yield and yield, quality of Indian ginseng (Ashwagandha) medicinal materials

- Fresh individual yield (NSCT fresh) (kg): Each tuber/root is harvested separately and weighed immediately after harvest to determine fresh weight.
- Dry individual yield (NSCT dry) (kg): Tubers/roots are harvested and dried at 70 °C until the moisture content reaches 13%, then weighed to obtain dry individual weight.
- Theoretical yield (NSLT) (tons/ha): (Individual yield × planting density) / 1000.

- Actual harvested medicinal yield (NSTT) (tons/ha): The total mass of tuberous roots in each experimental plot is harvested. Roots are excavated, stems and leaves are removed, weeds are cleaned, and the entire root mass of the plot is collected, then converted to yield per hectare. Each treatment is harvested with three replicates.
- + Tuber/root length (cm): Measured from the root tip to the base.
- + Tuber/root diameter (cm): Measured at the widest point of the tuber/root.
- + Fresh-to-dry ratio of the medicinal material.

2. 7. Data analysis

Experimental data were summarized and statistically analyzed using Statistix 10.0 software. The effects of planting season on the evaluated parameters were assessed by one-way analysis of variance (ANOVA). Treatment means were separated using the Least Significant Difference (LSD) test at the 5% significance level ($p \leq 0.05$).

3. RESULTS AND DISCUSSION

3. 1. Effects of planting season on survival rate and growth duration

The survival rate of different treatments was monitored from planting until the plants had completely recovered and the number of Indian ginseng plants had stabilized per unit area. The results obtained are as follows: The growth cycle of Indian ginseng under field conditions begins from transplanting seedlings to the harvest of medicinal materials. To evaluate the effect of planting time on the growth and development duration of Indian ginseng, we monitored the period from planting to tuberous root harvest.

Table 1. Effects of planting time on survival rate and growth duration of Indian ginseng.

Planting time	Time from planting to... (days)					Survival rate after planting (%)
	Root establishment and recovery	Branching	50% flowering	50% fruit maturity	Harvest	
5/1	10	35	75	85	200	77.67
5/3	5	25	65	75	180	90.57
5/5	12	45	85	90	210	66.23
5/8	6	25	70	85	190	92.70
5/11	10	45	75	90	200	85.70
LSD _{0.05}	—	—	—	—	—	5.13
CV (%)	—	—	—	—	—	6.3

Stage from transplanting to root establishment and recovery

The period from planting to root establishment and recovery ranged from 5 to 12 days depending on the planting season. Plants established in March and August recovered most rapidly, requiring only 5–6 days, whereas those planted in May required the longest period (12 days). This indicates that environmental conditions during March and August were more favorable for post-transplant establishment and recovery.

Stage from transplanting to branching

The period from transplanting to branching ranged from 25 to 45 days depending on the planting season. Plants established in March and August branched earliest, requiring only 25 days, whereas those planted in May and November exhibited the longest branching period (45 days). These results suggest that environmental conditions during March and August were more favorable for vegetative growth and branch development.

Stage from transplanting to 50% flowering and 50% fruit maturity

The period from transplanting to 50% flowering ranged from 65 to 85 days depending on the planting season. Plants established in March flowered earliest, reaching 50% flowering at 65 days after transplanting, followed by those planted in August (70 days), whereas the May planting required the longest period (85 days) (Shanmugaratnam, S et al. 2013) [19]. This indicates that environmental conditions during March and August were more favorable for reproductive development.

Stage from transplanting to harvest

The period from transplanting to harvest of Indian ginseng ranged from 180 to 210 days. Different planting times resulted in different harvest times. Planting in March and August led to the earliest harvest, at 180–190 days after transplanting. Planting in January and November required about 200 days, while planting in May required 210 days to reach the standard for harvesting rhizomes as medicinal materials.

Survival rate after transplanting (%)

The survival rate after transplanting ranged from 66.23% to 92.70% depending on the planting season. The highest survival rate was recorded in the August planting season (92.70%), which was not significantly different from that of the March planting season (90.57%), but was significantly higher than those of the other planting seasons. The lowest survival rate was observed in the May planting season (66.23%). These results indicate that March and August were the most favorable planting seasons for plant establishment and survival.

3. 2. Effects of planting season on growth and development

Appropriate scheduling of planting time helps ensure a high survival rate of plants under field conditions. In addition, planting time plays a crucial role in determining the growth and development of crops. The results of monitoring the effects of planting time on the growth and development of Indian ginseng are presented in Table 2.

For plants to grow and develop, the earliest manifestations are increases in plant height and the number of branches. Although planting in May was supplemented with moisture

through management and irrigation, prolonged high temperatures and intense heat adversely affected plant growth under field conditions, as reflected by the lowest plant height and number of branches per clump. At harvest, plant height averaged 125.6 cm per plant, the number of branches per clump averaged 2.5 branches per plant, and the number of primary branches averaged 5.6 branches per plant. In contrast, planting in August resulted in the best growth parameters at a 95% confidence level, and the plant growth rate was also the highest. Under this planting time, plant height reached 145.4 cm, the number of branches per clump averaged 4.3 branches per plant, and the number of primary branches averaged 9.2 branches per plant.

Table 2. Effects of planting time on selected growth and development parameters of Indian ginseng.

Planting time	Plant height (cm)	Number of branches per clump (branches)	Number of primary branches (primary branches)
5/1	130.8	3.1	7.4
5/3	135.5	3.5	7.8
5/5	125.6	2.5	5.6
5/8	145.4	4.3	9.2
5/11	130.5	2.9	5.6
LSD _{0,05%}	9.45	0.50	0.51
CV%	5.9	10.5	5.9



Figure 3. Indian ginseng plants after 60 days of planting.



Figure 4. Indian ginseng plants after 120 days of planting.

Among the planting times evaluated, the August planting showed the best vegetative growth, with the greatest plant height (145.4 cm), number of branches per clump (4.3), and number of primary branches (9.2 plant), significantly exceeding those of the other planting times ($p \leq 0.05$). Growth parameters recorded for the January, March, May and November plantings did not differ significantly ($p > 0.05$).

The August planting season resulted in the highest plant height (145.4 cm), number of shoots per clump (4.3), and number of primary branches (9.2 plant⁻¹), with significant differences compared to the other planting seasons ($p \leq 0.05$). These results are consistent with Singh et al. (2018), who reported superior Ashwagandha growth under rainy-season planting conditions.

3. 3. Effects of planting season on yield and quality

Vegetative growth parameters, including plant height and branching, were markedly influenced by planting season. Similar trends have been reported in other studies, where optimal climatic conditions promoted vigorous vegetative development and biomass accumulation in *W. Somnifera*. The effects of planting time on yield components and yield of Indian ginseng were monitored, and the results are presented in Table 3.

Table 3. Effects of planting time on yield components of Indian ginseng.

Planting time	Tuber length (cm)	Tuber diameter (cm)	Fresh individual yield (g/plant)	Dry individual yield (g/plant)	Fresh/dry ratio	Theoretical yield (t/ha)	Actual harvested yield (t/ha)
5/1	33.41	3.36	73.02	23.71	3.08	1.30	0.89
5/3	39.27	3.51	95.06	30.80	3.09	1.69	1.17
5/5	33.97	3.24	71.32	23.08	3.09	1.27	0.86
5/8	41.80	3.57	96.53	31.44	3.07	1.72	1.21
5/11	38.44	3.33	70.35	22.84	3.08	1.26	0.85
LSD _{0,05}	6.32	0.43	7.67	2.49	-	-	0.07
CV (%)	11.6	8.8	6.5	6.5	-	-	6.8

Tuber size

The average tuber length across planting times ranged from 33.41 to 41.80 cm, while tuber diameter ranged from 3.24 to 3.57 cm, with the highest values recorded for the August planting time and the lowest for the January planting time. Statistical analysis showed no significant difference in tuber size between the August and March planting times; however, significant differences were observed compared with the January, May and November planting times at the 95% confidence level.

Fresh individual yield

Fresh individual yield was highest in the August ($96.53 \text{ g plant}^{-1}$) and March ($95.06 \text{ g plant}^{-1}$) plantings, significantly exceeding that of the other planting times ($70.35\text{--}73.02 \text{ g plant}^{-1}$) ($p \leq 0.05$). This contributed to the higher harvested yields obtained in these planting seasons.

Fresh-to-dry ratio of medicinal material

The fresh-to-dry ratio of Indian ginseng tubers is governed by the plant's genetic characteristics and is not affected by planting time. The fresh-to-dry ratio ranged from 3.07 to 3.09, with no significant differences among planting times (Prater, C. A *et al.*, 2006) [20].

Theoretical yield

Theoretical yield is an indicator reflecting the maximum potential yield achievable under specific field conditions. It is determined by planting density and individual yield; thus, at the same planting density, higher individual yield leads to higher theoretical yield and consequently, greater actual harvested yield (Kumar *et al.*, 2008) [3]. The August planting time resulted in the highest individual yield and, therefore, the highest theoretical yield of 1.72 tons dry matter per hectare, while the lowest theoretical yield (1.26 tons dry matter per hectare) was observed for the November planting time.

Actual harvested yield

Actual harvested yield was significantly affected by planting time. The highest yields were recorded in the August (1.21 t ha^{-1}) and March (1.17 t ha^{-1}) plantings, with no significant difference between these two treatments, but both were significantly higher than those of the remaining planting times ($0.85\text{--}0.89 \text{ t ha}^{-1}$) ($p \leq 0.05$). The higher yields obtained in March and August were likely attributable to improved plant establishment and growth, resulting in greater root development and dry matter accumulation.



Figure 5. Fresh Indian ginseng medicinal material.



Figure 6. Dry Indian ginseng medicinal material.

3. 4. Pest and disease resistance

a) Status and prevalence of insect pests on Indian ginseng

Indian ginseng was mainly affected by cutworms (*Agrotis ipsilon*) and red spider mites (*Tetranychus* spp.), which are common pests in medicinal and vegetable crops under warm conditions (Van Leeuwen *et al.*, 2010) [21]. The recorded results are as follows:

Table 4. Composition and prevalence of insect pests on Indian ginseng.

No.	Vietnamese name	Scientific name	Damaged plant part	Damage level	Period of occurrence
1	Cutworm	<i>Agrotis ipsilon</i>	Leaves	+	March, June, August
2	Red spider mite	<i>Tetranychus</i> sp.	Leaves	++	June, July, August, September

Notes

- : Very rarely encountered, incidence < 5%;
- + : Low occurrence, incidence > 5% to 20%;
- ++ : Moderate occurrence, incidence > 20% to 50%;
- +++ : High occurrence, incidence > 50%.

Symptoms

Cutworm: Usually causes damage at night by feeding on young leaves or cutting through stems and young branches at ground level. Larvae are dark gray or grayish-brown, with faint black spots along both sides of the body.

Red spider mite: Red spider mites typically live in colonies and damage the underside of Indian ginseng leaves by feeding on the epidermis and piercing sucking plant tissues, causing leaves to turn yellow. The upper leaf surface shows scattered yellowish-white mottled spots, while the underside has fine white speckles; upon close observation, a very thin web layer can be seen. Red spider mites cause damage under dry and sunny conditions, with the most severe infestations occurring from June and during October -December.

The survey identified two major insect pests on Ashwagandha under Hanoi conditions, namely the black cutworm (*Agrotis ipsilon*) and red spider mite (*Tetranychus* sp.). Among them, red spider mites were more prevalent and occurred mainly during the hot and dry months, whereas black cutworms were only occasionally observed, primarily at the seedling stage. Similar observations were reported by Kumar *et al.* (2008) and Singh *et al.* (2010), who recognized these species as common pests of Ashwagandha, particularly under warm and dry environmental conditions. Overall, pest incidence remained at low to moderate levels and did not significantly affect plant growth or yield, indicating a relatively good adaptation of Ashwagandha to the ecological conditions of the study area.

b) Status and prevalence of diseases on Indian ginseng

Field surveys and monitoring indicated that two major diseases occurred on Indian ginseng, namely collar rot and leaf spot, being the most frequently observed diseases, consistent with reports on soil-borne and foliar pathogens in medicinal plant cultivation. The results on the occurrence and prevalence of diseases on Indian ginseng are presented in Table 5.

Table 5. Composition and prevalence of insect pests on Indian ginseng.

No.	Vietnamese name	Scientific name	Damaged plant part	Damage level	Period of occurrence
1	Collar rot	<i>Rhizoctonia solani</i>	Roots	+	June, July, August
2	Leaf spot	<i>Alternaria alternata</i>	Leaves	++	May, June, August

Notes

- : No disease observed; not detected
- + : < 10% of plants infected; not prevalent
- ++ : 11–25% of plants infected; low prevalence
- +++ : 26–50% of plants infected; prevalent
- ++++ : > 50% of plants infected; highly prevalent

Symptoms

- *Collar rot disease*: Usually causes damage at night by feeding on young leaves or cutting through stems and young branches at ground level. Larvae are dark gray or grayish-brown, with faint black spots along both sides of the body.
- *Leaf spot*: Leaf spot disease causes damage during the stage when the plant is vigorously developing its shoots and leaves and approaching flowering. Typical early symptoms include spots that may be yellow, dark brown or black, which gradually develop a concentric ring pattern. Yellow halos may appear around the spots as they darken, and newly formed spots may appear lighter during sporulation. If not properly managed, the number of spots on the leaves will progressively increase. Affected leaves may also wilt due to disease damage. Over time, the leaf spots can coalesce into large lesions, causing the leaves to wilt and eventually die.

Control measures

Maintain field sanitation by removing and destroying crop residues infected with pests and diseases before planting and after harvest; plow and expose the soil to sunlight. Plant at appropriate density and spacing, avoiding overly dense planting.

Apply antagonistic fungi such as *Trichoderma* to the soil to suppress soil-borne pathogens. Increase calcium supplementation to enhance plant resistance and help reduce disease incidence. In cases of severe disease infestation, the following plant protection products may be applied:

- Collar rot disease:

Before planting, mix preparations containing *Trichoderma*, *Chaetomium*, and *Bacillus* with bio-organic fertilizer and apply as basal fertilization to prevent soil-borne diseases. When collar rot appears and disease incidence is $< 10\%$, treatment can be carried out using biological active ingredients such as *Bacillus subtilis* (e.g., Bionite WP, Biobac 50WP), *Chaetomium* sp. + *Trichoderma* sp. (Mocabi SL), or validamycin (Tung Vali 5WP, 5SL; Validan 5WP). When disease incidence is $\geq 10\%$, chemical fungicides containing azoxystrobin + difenoconazole (e.g., Amistar 325SC, Trobin 325SC) or chlorothalonil (e.g., Daconil 75WP, 500SC; Arygreen 500SC) should be applied in combination.

- Leaf spot disease:

Biological products containing *Bacillus* (e.g., Bionite WP, Biobac 50WP, Mocabi SL) can be used for early-stage disease prevention when symptoms first appear. When the disease becomes more severe, fungicides containing azoxystrobin + difenoconazole (e.g., Amistar 325SC, Trobin 325SC) or chlorothalonil (e.g., Daconil 75WP, 500SC; Arygreen 500SC) may be used.



Figure 7. Red spider mite disease.



Figure 8. Leaf spot disease.

The monitoring results revealed the occurrence of two major diseases affecting Ashwagandha (*Withania somnifera*), namely collar rot caused by *Rhizoctonia solani* and leaf spot caused by *Alternaria alternata* (Table 5). Among these, leaf spot was observed at a low to moderate level of occurrence (++) , mainly from May to August, whereas collar rot was recorded at a low level of occurrence (+), primarily during the seedling stage from June to August.

Collar rot commonly developed under conditions of prolonged soil moisture, poor drainage, or high planting density. Infected plants exhibited soft rot and constriction at the collar region, resulting in lodging and eventual plant death. Leaf spot disease, on the other hand, developed rapidly under conditions of high temperature and humidity, producing brown to black circular lesions on leaves. These symptoms reduced the photosynthetic area and adversely

affected biomass accumulation. These findings are consistent with those reported by Kulkarni, S. K. (2008), who identified *Rhizoctonia solani* and *Alternaria alternata* as two of the most common pathogens affecting Ashwagandha cultivated in medicinal plant-growing regions of India. According to these authors, disease outbreaks are particularly severe during the rainy season or in areas with persistently high soil moisture. Similarly, Singh G et al. (2010) reported that leaf spot caused by *Alternaria alternata* is one of the major diseases responsible for reductions in both yield and medicinal quality of Ashwagandha when not properly managed.

Overall, the incidence of pests and diseases on Ashwagandha under the experimental conditions was relatively low, ranging from low to moderate levels of occurrence. These results suggest that Ashwagandha possesses relatively good resistance and adaptability to the common pest and disease complexes present in the Hanoi region. Nevertheless, the implementation of an integrated pest management (IPM) strategy, combining cultural, biological, and judicious chemical control measures, is recommended to minimize pest and disease outbreaks, thereby ensuring stable yield and high-quality medicinal raw materials.

The survey further confirmed that collar rot caused by *Rhizoctonia solani* and leaf spot caused by *Alternaria alternata* were the two principal diseases affecting Ashwagandha. These findings are in agreement with previous studies on *Withania somnifera* in India, where *Rhizoctonia solani* was identified as a major causal agent of collar rot during the seedling stage, while *Alternaria alternata* was recognized as one of the most common foliar pathogens responsible for significant reductions in yield and medicinal quality.

4. CONCLUSIONS

The suitable planting schedule for Indian ginseng is sowing seeds in January and transplanting in March, which results in a survival rate of over 90% and an actual harvested yield of 1,17 tons dry matter per hectare. Alternatively, sowing seeds in June and transplanting seedlings in pots in August each year yields a survival rate of over 92% and the highest actual harvested yield of 1,21 tons dry matter per hectare, making this schedule the most suitable for the Red River Delta region. Indian ginseng is commonly affected by cutworms, red spider mites, collar rot and leaf spot disease. Timely and appropriate control measures are therefore necessary upon detection of pests and diseases.

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