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Effects of the Physical and the Chemical Characters of Soil on Ginseng Quality and Yield

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The physical and the chemical characters of high-yield soil and low-yield soil for planting ginseng were analysed in order to evaluate the effects of the physical and the chemical characters of soil on ginseng yield and quality.

The comparison of physical characters between high-yield soil and low-yield soil for planting ginseng. The results in Table 1 showed that the high-yield soil for planting ginseng was characterized by porous, light unit weight, high total porosity and capillary porosity, and high content of storage moisture. Those characters were beneficial to ginseng growing.

Table 1. The differentiation of physical characters between high-yield soil and low-yield soil*

Soil	Specific gravity (g/cm^3)	Unit weight (g/cm^3)	Total porsity (%)	Capillary porosity (%)	Moisture (%)	Effective storage (%)	Field capacity (kg/m^2)	Ginseng yield
Low-yield	2.63	1.18	54.97	27.85	18.43	9.75	23.17	1.03
High-yield	2.40	0.85	65.17	59.90	48.04	36.61	86.45	2.25

* The soil samples were taken from 0~20 cm depth of the soil.

The comparison of chemical characters between high-yield soil and low-yield soil for planting ginseng.

Table 2. The differentiation of the chemical characters between high-yield soil and low-yield soil

Soil	pH	Replaceable capacity (mgE/100g soil)	Salt base saturation capacity (%)	Organic matter (%)	Quick-acting N (%)	Quick-acting P (%)	Quick-acting K (%)	Ginseng yield (kg/m^2)
Low-yield	6.4	17.70	43.40	2.08	129.8	13.5	413.9	1.03
High-yield	5.5	29.34	61.60	19.48	141.9	50.5	471.4	2.25

It was evident (Table 2) that the high-yield soil was being of higher replaceable capacity and salt base saturation capacity and contained more organic matters and more quick-acting nitrogen, phosphate and potasium as compared with those of low-yield soil for planting ginseng.

The amelioration of some physical and chemical characters of low-yield soil after being improved and its effect on ginseng yield.

Some physical and chemical characters of low-yield soil were improved greatly after the soil were ameliorated (Table 3) and the ginseng yield were increased by 125.3% over than that of unimproved soil.

Table 3. Comparison of some physical and chemical characters of the soil before improving and after improving

Treatment	Unit weight (g/cm^3)	Total porosity (%)	Moisture : Porosity : Solid (%) (%) (%)	Organic matter (%)	Ginseng yield (kg/m^2)
Before improving	1.09	41	35. 1 : 5.9 : 59.0	2.15	0.95
After improving	0.895	66	23.27 : 34.0 : 34.0	9.75	2.15

The content comparison of efficacious elements in the red ginseng processed from the roots cultivated by improved technique with those cultivated by ordinary technique.

After summing a series of experiments, we developed a new ginseng cultivative technique which took the soil improvement as a key. As compared with the oridnary cultivative technique, the yield was increased 50.0% and the rate of high quality ginseng was increased 56.0% by taking the improved technique. The content of efficacious elements in the red ginseng processed from the six-year old ginseng cultivated by improved technique were much higher than those cultivated by ordinary technique (See Table 4).

Table 4. The content comparison of efficacious elements in the red ginseng processed from the roots cultivated by improved technique with those processed from the roots cultivated by ordinary technique

Cultivated technique	Total ginsenosides (%)	Total amino acids (%)	Volatile oil (%)	Saccharides (%)
Improved technique	5.131	11.273	0.113	58.376
Ordinary technique	3.895	9.540	0.025	56.106

Conception for Wild *Panax ginseng* Diversity Preservation in Russian Primorye

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The wild plants of *Panax ginseng* C.A. Meyer are represented in Primorye by some isolated small populations. Genetic diversity of plants of these populations can be of great importance for future breeding program and for preservation of this species included in the Red Book.

The authors developed the conception of panax preservation operating on some levels of preservation. The conception included protection of wild plants in their natural habitats, establishment of natural reserves and zones under protection. The living collections and long-term crio-band are significant elements of this conception.

Physical Chracteristics of Soils Cultivated with Ginseng

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The fundamental physical properties of main soils cultivated with Ginseng in Jilin province, 8 samples of Dark Brown Soil and 10 samples of planosol, are characterized and the results are the followings:

1. The physical sand is the major component of particle composition, making up 50~60% of whole soils. The soil textures are loam, silty loam or heavy loam, and the uniform period of 3 or 5 years. The water stable aggregates of more than 0.25 mm in diameter is 45~67% of total amount, and among them, the most valuable portion (0.5~2 mm diameter) for practice are 55~70% in the Dark Brown Soils and 26~40% in planosols. The aggregate quantity of Dark Brown Soils (structural index 85~90%) is better than that of planosols (structural index 22~28%). The bulk densities range 0.67~1.05 g/cm^3, total porosities 60~75%, the aeration porosities with equivalent pore diameter of >0.2 mm 10~20%, the water-holding pore with a diameter of <0.2 mm 44~64%, and the air capacities under 10 KPa water tension 25~40%. The plant available water capacities under 6 KPa and 10 KPa tension are 32~46 % and 30~40%, respectively. The specific water capacities (water supplying capacity under given water tension) under 6 KPa and 60 KPa are 4.27×10^{-1}~5.86×10^{-1} and 5.0×10^{-2}~7.4×10^{-2} ml/cm^3.KPa. The available water contents between 1.5~6.0 KPa range 15~34%, and the difficult available water contents of >60 KPa tension are about 26~32%. All above indicate that the physical properties of Ginseng cultivated soils in Jilin can satisfy the requirements of Ginseng development for moisture, permeability, friability and weak cohesion.

2. The structure and the ratio of physical sand to physical clay of ginseng cultivated soils is closely and positively related to Ginseng yield and other physical properties. Hence, Wen recognize that the structureness is the basic of other physical properties for the bed soil made of Dark Brown Soils, which rich in quantitied aggregates, and the wet aggregate quantities range about 60% and Ginseng yield is relatively high. But for the bed soils made planosols, with heavy texture of poor aggregates, the sand/clay ratios control the behavior of other physical properties and Ginseng yields high when the ratio is about 6 : 4.

3. During the cultivation, the variation of physical properties of bed soils display the accumulation of clay in upper layer, decrease of aggregate contents, increase of bulk densities, decrease of total porosity, water supplying capacity, but only increase of soil water-holding capacity. It is obvious the consumption of organic matter and leaching loss of base ions result in collapse of big aggregates and further damages the other physical properties of bed soil. Therefore, this may be the soil reason for the poor efficiency of Ginseng continous cropping.

4. Increased water-holding capacity and decreased permeability were related with heavy texture and poor aggregate are the key reason for Ginseng red-coat disease occurrance. Therefore, the physical properties of Ginseng cultivated soils are closely associated with Ginseng red-coat disease.

5. The soil bulk density closely relates to soil structure, total porosity, permeability, water-holding capacity, and water supplying capacity, and the correlation coefficients are 0.963*, −0.999**, −0.988**, −0.955**, and −0.962**. So, We propose that the bulk density (about 0.8 g/cm^3) could be used as an index for estimating physical propertys quantity or suitability of Ginseng bed soils.

Application of Gaseous Fertilizer of Carbon Dioxide in Cultivating Ginseng

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The experimental materials were the ginseng (*Panax ginseng* C.A. Meyer) 1 to 5 year-old roots which had passed the dormant period. They were planted in plastic shed in spring. Untill the seedings grew neatly, each day from 5 to 7 hours Beijing time used 500 to 600 ppm CO_2 fertilizer for them, which lasted 30 days. CO_2 gas was produced by burning liquefied petroleum gas (LPG) the CO_2 content was determined by the infrared ray CO_2 analytical instrument (QGD-07 type).

The analytical results of some relative parameters of ginseng development and some physiological target, the field and the total ginsenoside content indicated that using CO_2 fertilizer obviously promoted ginseng's development, increased the stem thickness, the height, the area of leaves, the numbers of root fibrils, the weight of ginseng's fruit and seed, which the thousand seed weight was average increased 6.21%. It also got a raise of 13 to 74% in the leaves chlorophgyll content, especialy obvious in 3 to 4 year-old plant, with the photosynthesis was promoted the dry substances added 0.24 to 36.74%. The root weight was average increased 2.3 to 28%, the short year-old plant reached 15 to 28%. The total ginsenoside content got 16 to 75%, also the short year-old better. So we concluded that the CO_2 gas fertilizer had a better effect in the short year-old ginseng plant especialy and that the technique could be used to industral growing seedlings in protective

Nitrogen Mineralization Potentials of Albric Ginseng Soil in Jilin Province

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In order to research nitrogen mineralization potentials of ginseng production areas in Jilin province, to solve the problem which nitrogen affected on the ginseng production and to offer some theoretical evidence, the study was firstly conducted by a new approach of aerobic culture and intermittent leaching, which was proposed by Standford and Smith. The samples of ginseng soils were obtained from 14 ginseng farms in Fusong, Jingyu and Changbai county, etc.

In the incubation experiment, cumulative net N mineralization (N_t) was linearly related to the square root of time ($t^{1/2}$) throughout 112-day period of intermittent incubation ($r^2=0.97^{**}\sim0.99^{**}$, $n=14$). The slopes increased with the increase of fertility level in ginseng soils. This result fitted in with the field experiments and production practices.

The N mineralization potentials (N_0) were measured by Stantford's methods in the incubation experiment. Since ginseng soils are generally high in the contents of organic matter and total N(O. M. from 6. 6% to 17.9%, T. N. from 0.32% to 0.89%), and very near to natural soils, its fertility factors were stabler than field soils, the unstable factors came from the inner and outer of soil had a little effect on N_0. All these characteristics were very different from field soils. In the all incubation period, the trends of mineralized N in various short periods were stable and regular. Therefore, the sum of net N mineralization should include the N mineralized of initial incubation when it was used to estimate n_0.

The N_0 of ginseng soils was correlated positively with the total N, hydrolyzed N and organic matter. In the path analysis, the direct (0.8886), indirect (0.8461 and 0.8624) and partial correlative (0.6594) coefficients are all first between hydrolyzed N and N_0. It indicated that the hydrolyzed N contributed greatly to N_0.

The mineralization rate constants (K) of these 14 ginseng soils are from 0.074 to 0.093, there was no difference among the rate constants. The weighted average value is 0.084± 0.0026. That shows the mineralizable N is released at an average rate of 8.4% per week, which can meet the needs of the nitrogen nutrition for ginseng growth. Although N fertilizers were not applied to this kind of soils, the goal of good quality and high yield of ginseng could be gotten.

Difference of the N mineralized between the soils were mainly caused by the N_0 variances but not by mineralization rate constants. The half-time for N mineralization of the 14 ginseng soils ($t_{1/2}$) is from 8.25± 0.71 week.

Studies on the Effects of Using Different Methods of Soil Disinfection to Increase the Yield of Gingeng Planted on Farm Land

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Two plant diseases of ginseng root, caused by rust rot funguses of ginseng (*Cylndroscopon* sp.) and root rot funguses of ginseng (*Fusarium* sp.), seriously reduce its yield and quality, especially when grown on farm land. Sometimes, the diseases blight and perish ginseng plant.

This research is concerned with how to prevent and eliminate the diseases by using biological, physical and chemical methods of soil disinfection to increase the yield of ginseng. The results are as follows:

Green mildew funguses (Trichodermaviride pers. ex Fr.) could stand up to the root rot funguses of ginseng and reduced the incidence of the diseases when applied to the farm land; The emulsion of D-D (1,3-dichloropropane 1,3-propylene chloride) could be used as a disinfectant of soil on farm land growing ginseng. Before the soil was disinfected by D-D, it had to be turned, harrowed and dried in the sun several times. And then the green mildew funguses were applied to the soil. With this done prior to planting ginseng, the yield of six-year-old ginseng could rise to 2.29 kg/sq.m. and 53.2g per root on average. The rate of first and second finished products of ginseng reached to 90.33% and the rate of rust root was cut down to 53.19%. Moreover, using this method when planting ginseng on farm land, the relative rate of prevention of the diseases was 80.79%.

Influence of Boron on the Grownth, Development and Matter Accumulation of Ginseng

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The influence of boron on the growth, development and matter accumulation of 2-year-old ginseng plants was studied by the hydroponics at different concentration of boron.

The symptoms of born deficiency was that the leaf green-faded near its vein, presenting some transparent, hymenopterous spots; there were some red-brown pigmentation on the surface of petioles, tips and margins, absorptive roots reduced and shortened with a rust tip.

If the boron in two-year-old plants was deficient and excessive, the content of chlorophyll decreased 4.15 mg/m*l*·cm^2 and 2.42 mg/m*l*·cm^2 and photosynthetic rate decreased 0.597CO_2 mg/dm^2·h and 0.410CO_2 mg/dm^2·h, respectively.

If the boron in the 2-year-old plants was deficient and excessive, the content of ginsenosides in the roots reduced by 1.28% and 1.26%, and that of total saccharides reduced by 13.75% and 9.16%, respectively. The content of boron was positively related to the boron concentration in the nutritive solution. If the experimental concentration on the 2-year-old plants was 0.00～0.4 mg/1, the correlation equation of roots;

$$Y=4.14+25.16x,\ r=0.960$$

that of stem and leaves

$$y=10.01+66.82x,\ r=0.956;$$

The relationship of single plant yield to boron concentrations in the nutritive sotution was a cubic regression equation. The equation of the dry weight of whole plant (y, mg)

$$y=230.6+5771.9x-36995.8x^2+56815.8x^3,\ r=0.976$$

That equation of dry weight of root

$$y=148.3+7532.4x-68343.3x^3,\ r=0.999$$

The optimal concentration of boron in the 2-year-old plants was 0.08 mg/*l* and the critical concentrations of boron-defiency and boron-excess were 0.01 mg/*l* and 0.60 mg/*l*, respectively.

To sum up, if the boron in ginseng plant was deficient or excessive, the photosynthetic capacity was weakened, the synthesis and transportation of carbohydrates were inhibited, the yield and effective compenents were decreased and the quality was not good enough.

Growth Regularity of Wild Ginseng

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Wild ginseng and cultivated ginseng (*Panax ginseng* C.A. Mey.) belong to identical species, but there are some differences in their morphology and growth regularity because of their ecological environment. The wild ginseng has a low propagation coefficient, slow growth and unique root form. It can be seen from our investigation that the growth years and plant morphology change of the wild ginseng differ from those of the cultivated ginseng. A majority of the 10-year-old wild plants has one palmate leaf and a minority has two. A majority of the 20-year-old wild plants has two plamate leaves, a minority has one or three and a tiny minority has four. A majority of the 30-year-old wild plants has three palmate leaves and a minority has four. A majority of the 30-year-old wild plants has three palmate leaves and a minority has four. A majority of the 40-year-old wild plants has four or five palmate leaves. The wild plants that have been more than 50-year-old produce six palmate leaves and reach adult. In the normal growth under the forest, the plant growth needs 5~10 years from one sort of morphology to anothr one. Under an adverse condition, there even is a reverse change, i.e. from three palmate leaves to two or one.

In general, the root system of wild ginseng grown in a 5~18 cm humus-rich soil, being characterized that the main root and branch roots grow vertically in the stage of the trifoliolate or one palmate leaf (except for the reverse change plants) and the branch roots and fibrous ones grow horizontally after three palmate leaves stage, and distribution area of the large root system in the soil is roughly similar to the nutritive area of the aerial parts, having an extending range of 30~50 cm in diameter.

We collected more than 430 plant samples that were various years old by digging in the mountains and purchasing in the stations for wild ginseng. On the basis of different growth years, the samples were studied and the data were analysed by a computer. The results showed that the average root weight of 50-year-old wild ginseng was 25.00± 3.21g with a yearly average weight gain of about 0.5g, while that of 80~100 year-old was 55.83± 12.37g with the gain of about 1g and that of 150-year-was 296.25± 12.37g with the gain of about 2g. The wild ginsengs that have been more than 100 years old have a rapid root weight gain because the gradually increasing nutritive area in the aerial parts (Some plants changed from single stem into multiple stems) makes photosynthetic products increase and promotes the growth of the root system and because, on the other hand, the adventitious roots on the rhizome grow gradually as the growth years increase. Therefore, the more the growth years of wild ginseng are, the more the root weight gain is.

Inadequate illumination is a main reason for the slow growth of wild ginseng. In the air temperature of 20~25℃, an appropriate illumination for the cultivated ginseng is 20,000~30,000 Lux, but the average illumination of wild ginseng is that the root systems of other plants contend with those of wild ginseng for the nutrients and water in the soil.

An Ecological Distribution of V_A Mycorrizal Fungi in Ginseng (*Panax gineng* C.A. Meyer) in ChangBai Mountainous Area in the Northeast of China

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An ecological distribution of V_A mycorrizal (V_AM) fungi of Ginseng cultured in lessive soil of Changbai mountainous area in the northeast of China was investigated. We found that rates of V_AM infection

were 43%, 54% and 62% for 4-, 5-and 6-year Ginsengs in summer (June), respectively, and those were 14%, 12% and 9% in autumn (September). It is suggested that the rate of V_AM infection was varied with ages and with growth periods at the same age. It is also found that the densities of VAM fungi spores in soil were 140, 106 an 96 spores per 100g soil for 4, 5-and 6-year Ginseng, respectively, in summer and those were 152, 143 and 120 per 100g soil in autumn, decreasing with the increase of the ginseng ages. There seems to be no inevitable relationship between spore density and infection rate. It was shown that ACAULOSPORA spp was the predominant type for forming VAM in Ginseng, followed by GLOMUS spp, and SCLEROCYSTIS spp. The influence of soil pH, phosphorus and extract of Ginseng on the VAM fungi in Ginseng was discussed in this paper.

Studies on the Law of Infected Ginseng Leaf by Phytophtora Cactorum

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Ginseng leaf inoculated with a sporangial suspension (450/m*l*) of *Phytophthora cactorum* were used to determine the effects of wetness duration and temperature on infection level.

Infection index increased with increased wetness duration (8～32 hr) at all temperature tested (6～30 ℃) for each wetness duration, the infection index increased with temperature and were up to an optimum at 25℃ and then declined. Between 20℃ and 25℃, the wetness for 15 hr or over resulted in 50% infection. A multiple regression, logistic model accurately described infection as a function of wetness duration and temperature;

$$y=1/(1+e^{0.2193+0.5192-3.6416E-0.21^{2}+7.0362E\ \ 0.4T^{3}\ \ 1.1892E\ \ 0.4W^{2}}T)$$

The simulation fest for the model was conducted under laboratory condition.

Study of the Pathogenicity of Ginseng Bacterial Soft Rot in Jilin Province

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The isolates of bacteria obtained from diseased ginseng roots were examined for their pathogenicity, morphological under electron microscope and serological characteristics. The results that the pathogens causing ginseng bacterial soft rot in Jilin Province were *Erwinia carotovora* pv. carotovora Dye, *Erwinia carotovora* pv. atroseptica Dye and *Pseudomonas caryophylli* (Burkholder) Starr & Burkholder.

Study on the Biological Characteristics of *Fusarium solani* of Ginseng

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The biological characteristics of Fusarium solani of Ginseng were systematically studied in this experiment. The results showed that Fusarium solanis had a lush growth with no color spores, and two kind of spores took the shape of sickle and ellipse. The gerums growth temperature ranged from 10℃ to 25℃, and the optium ranged from 25℃ to 28℃. If the conditions were suitable, the spores grew into Germ-Colonies in three days. The growth pH ranged from 3 to 12, and the optium ranged from 6 to 7. The colonies also grew well on both Czepek and PDA media. The optimum nutrition of spores growth were both glucose and sucrose. Suitable relative humidity for Germs growth was over 83%. The terminal inactive paint was 10 min under the condition of 63℃. The effectiveness of Carbendazim, Aliette, Procymidone and Zineb was good to control the germs. All above provided a primary basis for control the disease.

Prospects for Studies on Control of Main Diseases and Insect Pests of Ginseng in Jilin Province

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In this paper, the control studies were reviewed on main disease and insect pests for 30 years since the middle-latter 1950s. The achievements in scienctific research were emphatically appraised about root diseases, withered diseases, black spot diseases, red skin diseases, soil insects and freezing pests of Ginseng. It was pointed out that all the achievements, including the basic surveys and studies on system laws, had made good effect on production. Hereafter, in the control studies of diseases and inset pests of Ginseng, base studies and utilization of high technologies for production should be augumented on the basis of spreading the achievements now available. It should be noticed to make resistance breeding works have a breakthrough by biological technologies when searching for source of resistance to diseases. Pay attention to the studies of high effective and low poision and remain pesticides to carry forward the studies on no environmental pollution. Perfect quarantine systems and enhance surveys to set up a forecast system which is suited to Chinese conditions and easy to be utilized, and form a comprehensive control measure. In the region of planting Ginseng, build a large and model of synthesis control on the pest of Ginseng to improve the control level of diseases and insect pests of Ginseng.

Survey and Primary Research on Chemical Control of Pests of Ginseng in Jilin Province

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This paper is a comprehensive report of survey and research on the pests of Ginseng-the rare Chinese medicinal herbs in the last few years. Pests of more than 50 species in Ginseng were described, which belong to 26 families of 9 orders respectively. The paper proposed that dominant species varied with the region and host population and pest population could be affected by soil condition and cultivation system. Adults and larvae of four kinds of scarab-common pests of Ginseng were indexed according to their morphological characters for identification. In chemical control, better results had been achieved with the soil treatments of 3% carbofuran and 5% granulated phoxim, 10~15g/m^2 and spray and irrigation of 50% phoxim (EC), 50% DDVP and 90% dipterex, etc.

Histopathology Anatomy of Ginseng Bacterial Soft Rot

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After being infected by Erwinia pv. carotovora for 2~144 hours under 24~25℃, ginseng tissues were scanned with electron microscope. The results indicated that the pathogenic bacteria orientated on the epidermis cells after two hours of inoculation. The pathogens increased and developed to ginseng internal tissues with the inoculation time. Most bacteria could be observed in every parts of ginseng after 6 days.

A Preliminary Study of Seed Pathology of *Panax quinquefolium*

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The main pathogenic fungi of *Panax quinquefolium* may enter the seeds in the early developmental stage of the host fruits. The leaf blight pathogen, *Alternaria panaxa*, was isolated from tender seeds when fruits were green. The causal agents of ginseng root rustrot, *Cylindrocarpon* spp. were obtained from the young seeds in red fruits. Among them, the dominant pathogenic species, *C. destructans*, was discovered in the middle parts of the host stem in the early stage of fruit development. The fungus reached the nodes of the pedicels in red fruit stage and entered the seeds. The fact that the occurence of the fungus gradually reduced from middle parts of the stems to the pedicel nodes in the course of fruit developement indicated the existence of a tendency that the pathogen spread from infested root system to the lower and upper parts of the plant, and finally enter the seeds before harvesting. The contamination percentage of the newly harvested seeds was not very high (3~5%, in general). In the course of the treatments for afterripening and gapping (a long period of 6~20 months) the percentage of the contaminated seeds increased rapidly due to the suitable moisture, temperature and aeration, etc. from 3.3% to 48% by the end of the first month, 92% by the second month and 100% by about 70 days. Around 85% of the contaminated seeds were infested by *C. destructans.* The development of seedborne fungi was evidently checked within the first two months in Dithane-M 45 treated seeds. But the contamination ratio of these seeds increased rapidly to 66% by the end

of the third month, and to 100% by 120 days. Among the seedborne fungi isolated from treated seeds 50% was *C. destructans*. This is the result of tenacious and ingenious adapition of the fungi to their host and its growing and developing conditions. And it is also a very typical case in seed pathology. Consequently, the following points merit our consideration in the whole course of seed treatment, A) Regular and multi-treatment of seeds with fungicide, such as Dithane-M45, B) Make an effort to search after and adopt long efficacious fungicide, C) Sterilize the sand, water and implements used in the whole course of seed treatment regularly and repeatedly.

Transmission Electron Microscopic Observation on Witches' Broom Disease of *Panax quinquefolium*

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Witches' broom disease of *Panax quinquefolium* was found for the first time in Zuojia, Jilin Province, China in 1989. Infested plants appeared with apparent stunt or witches' broom and smaller leaf. Sometimes plants severely infested grow deficiently, and even die qradually. It will cause a great economic loss in the production of *P. quinquefolium*. There was a large amount of circular, elliptic, or dumbbell-like Mucoplasma-like Organism (MLO) in the sieve tube cell of the diseased host under the transmission electron microscope, indicating that witches' broom disease is a MLO disease. The MLO was about 80～667 nm in length. Unit membrane was about 7.6 nm thick.

Some problems as the spread pathway, infective circulation and MLO carrier of witches' broom disease of *P. quinquefolium* were less known and some experiments are under going.

Studies on Root Rot of *Panax ginseng* and its Biologlcal Control

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Root rot is caused by *Cylindrocarpon destructants*. The fungi spead through soil, can infect all parts of root, and affect yield and quality of ginseng seriously. The disease occures in all the ginseng-producing countries. Now, it has become a major obstacle of development in ginseng production. Many scholars studied this disease and control it through soil distinfection and alternate husbandry. There are few reports about the biological control of this disease. Although biological control is less used to prevent and cure root rot, it will play an important role in future. Since 1960's we have studied the biological control of the root rot of ginseng with chemical control, physical control and alternate husbandry, the results are as follows:

1. Application of antagonistic fungi in dealing with nosogenetic soil

Among the application of antagonistic fungi and organism to the nosogenetic soil, Trichouderma Sp. (T_{76} and wormwood A selengnsis Turcz) had very good effects. Per unit-area yield was 2.65 kg/m^2, while that of CK is zero and the effects of other controls were less than that of this control.

2. Studies on Substrate of T_{75}

When there is supply nutrition in the soil, T_{75} will reproduce rapidly and take leading place among all fungi, fully play the function of antagonistic fungi. For selecting the best substrata, we studied antagonism of T_{75} in different substrate, i.e. the powder of corn stem, ginseng and wormwood. Inhibitory effectiveness of T_{75} to other fungi appeared in all the three substrata. The strength of antagonism of T_{75} was 30% in the powder of corn stem and that was 82% in the powder of ginseng, and the antagonism was the strongest in the powder of wormwood, over 90%.

The results of study in the laboratory were consistent with those in the field survey, showing that the effects of T_{75} and wormwood in dealing with root rot can be recognized.

Studies on Characteristics and Specific Property of Yellow-Fruit Ginseng

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Yellow-fruit ginseng (*Panax ginseng* C.A. Mey.) (YG) is a new type of ginseng introduced by our institute from Fu Song County, Jilin Province in the late of the 1950s, which obviously differs from red-fruit ginseng (RG). Through multi-year systematic cultivation in Zuojia District, Jilin City and observation and analysis in comparison with the red-fruit ginseng, we found that the YG is superior to the RG in many characters.

1. There is morphologically no significant difference between the YG and RG. Major differences between them are that for the YG, the stem and petiole are green and the matured fruit is cream-coloured, but for the RG, the stem and petiole are purple or puple-green and the matured fruit is red. The YG has stable genetic characters in stem and fruit colours.

2. As compared with the RG, the YG's date of seedling emergence is 1～2 days late, date of fruit maturity is 1～2 days early and growth is uniform. There is no significant difference between the YG and RG in the height of differently year old plants. But as compared with the RG, the YG's leaf is slightly short and wide, floral axis is slightly short, compound leaf rate of over three palmate leaves is high in the three-year-old plants and branching ability of the floral axis is high in the adult plants. The seed-set rate of the YG is slightly higher than that of the RG, having an average of 73 seeds per plant and 17.7% higher than that of the RG. The yield per unit area of the three-year-old seedlings of the YG is similar to that of the type of Ma-Ya ginseng, but is markedly higher than that of mixed strains and of the type of Chang-Bo ginseng. The commodity output of the YG is markedly higher than that of the Chang-Bo ginseng but does not markedly differ from the Ma-Ya Ginseng.

3. As compared with the RG, the YG's total saponin content has increased by 0.7%, total amino acid content by 0.81%, total volatile oil content by 0.9884% and total protein content by 2.29%, but its total saccharide content has decreased by 2.5%.

To sum up, the yellow-fruit ginseng is a middle-high yield type of ginseng, whose available component content is relatively high, and is a strain with a great future.

Studies on Inheritance of Major Agronomic Characters of *Panax ginseng*

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In this paper, 11 major agronomic characters of different types of ginseng (Da-ma-ya, Er-ma-ya, Yuan-bang-yuan-lu and Chang-bo-lu) were compared. It was found that the differences in 7 characters were significant, especially in yield per unit area, weight of single root, root diameter. etc. were extremely significant, which would provide a selection base for ginseng breeding for high yield.

Genetic analysis were conducted and genetic advance, genetic correlation and selection index were calculated for 5 main yield characters. Results showed that yield and its component factors in different types of ginseng had higher heritabilites, being advantageous to early generation selection. The weight of single root, root diameter and stem diameter were positively correlated with the yield per unit area at signifiant levels. The yield and its components had greater selection potentialities. The selection index deduced from the weight of single root+root diameter+stem diameter had the fastest genetic advance. It was the best selection program for ginseng plants.

The comprehensive evalution for the characters of different types of ginseng was conducted by selection index equation. It was found that Er-ma-ya had the greater selection index, the next was Da-ma-ya and Chang-bo-lu had the smallest index among the four types.

Induction and Analysis of Plant Induced From Filament of *Panax ginseng*

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Monokaryon stage flower buds of ginseng were kept for 3~7 days at 2~4℃, and tood the filament and cultured on the MS medium (6% sucrose) supplemented with BA (3 mg/*l*)+2,4-D5+LH3000 or with BA0.5+2.4−D2+LH3000. Induction frequency of callus were 91.7% and 94%, respectively. Callus was timely transferred onto a differentiation medium that was composed of MS salts+BA0.5+NAA3+IAA2 (or 4) and cultured at 18~23℃ under natural light and regenerated plant can be obtained, Induction frequency of regenerated plant was 2.4~11.9%. Regenerated plant can be subcultured on the same medium successively. Differentiation frequency has not decreased for 9 years. Cotyledon of degenerated plant were cut and cultured on a differntiation medium, regenerated plant can also be obtained, and the differentiation frequency was more than that of filament. The morpha of the regenerated plant include: dicotyledon, one compound leaf with 3 leaflet, one compound leaf with 5 leaflet, two compound leaf with 3~5 leaflet three or four compound leaf with 3~5 leaflet and two inflorescence (9 flower buds), Growth of the regenerated plant was 60~130 days in the bottle. Gemma can still germinate continuously after dormancy of low temperature, rootless plantlefs were transferred on 1/2 MS medium without plant gronth regulators and can produce root.

The saponins, all amino acid and essential amino acid for people contents of the root of regeneated

plant, which occurred and had grown for 90 days the same year, were more than that of 1 or 2-year-old field-grown ginseng root. Saponin content of stem and leaf of regenerated plant was more than that of 1-year-old field-grown ginseng stem and leaf.

Ginsenoside Synthesis in the *Panax ginseng* Calli Transformed by *Agrobacterium rhizogenes Strains*

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The transformed cultures were obtained from the wild plants collected in the Ussuri region in 1988. The plants of different age were cultivated in special pots and the young stems were inoculated with A4 or 15834 *Agrobacterium rhizogenes* strains. The stem tumours were explanted aseptically and cultivated on nitrate deficient MS media in the dark.

The ginsenoside content was tested in 22 callus lines of panax cells and each line was proved to accumulate the dammarane glycosides during 2 years of experiment. The content of Rg_1, Re, and Rb_1 varied in different lines from 0.5 to 4.2 mg per g of dry tissue. The maximum production of Rg_1, Rf, Re, NG-R_2, Rd, Rc, Rb_1, and Rb_2 ginsenosides reached 7.2 mg per g dry tissue and was close to their content in parent plants.

The lines of different origin produced ginsenosides in nearly the same proportion. Most of callus lines (with the exception of 4s and 2r lines) demonstrated the stable ratio in Rb/Rg and Rg_1/Re ginsenoside content. These ginsenoside ratios in callus lines differ substantially from those ones in the upper or underground parts of intact panax plant.

The transformed callus lines demonstrated the more rapid growth and more effective ginsenoside accumulation than nontransformed lines originated from the same plants.

Studies on Growing Ginseng Seedlings by the Nutrient Solution

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The ginseng seeds which had passed the dormant period were well-distributedly sowed in seedling plate where filled some sterilized sands. When the seedings stem got height of 4 cm and the root reached length of 4.5 cm, they were taken to the tin pot to go on the soil-less culture. The nutrient solutions were designed three compositions, they were aerated by chemical and artificial methods. When the seedlings were cultivated 120 days in glasshouse, we found that the ginsengs seedlings grew normally and it had many gemma in one root. The root weight was mean 1.21 g, it increased 37% compared with the seedling grew in ground (each root weight was mean 0.87g), and also the ginsenoside content was more than the contrast, the number one was best. Therefore the seedlings of soilless culture were taken to the ground, the flow pot or the river sands culture, they also grew normally, the rate of double gemma reached above 80%.

High-Frequency Plant Regeneration in Hybrid Embryos Culture of Ginseng

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In the present study, hydrid embryos at cotyledon stage from reciprocal cross of *Panax ginseng* and *Panax quinquefolium* were cultured on MS medium supplemented with plant hormones (with 0.7% agar), and many somatic embryos were induced. Results showed that the hybrid embryos from *P. ginseng*×*P. quiquefolium* easily formed somatic embryos as compared with those from *P. quinquefolium*×*P. ginseng*, the average rates of induction were 35.5% (the highest 100%) for the former and 18.2% (the highest 70%) for the latter.

All of the hybrid embryos from the reciprocal cross could develop into shots if they were transferred onto 1/2 strength MS medium supplenethed with appropriate hormone combinations. The average induction rates of complete plants with roots, stem and leaves in *P. ginseng*×*P. quinquefolium* were higher than those in *P. quinquefolium*×*P. ginseng*, being 75.2% and 69.8%, respectively.

The form of the regenerated plantlets varied from trifoliolates to three palmate leaves and the majority of the plantlets was clustered.

The regenerated plantlets were transferred onto a modified N_6 medium without plant hormones to make them sturdy. The height of the plantlets was about 8 cm with distinct main root and lateral roots, and the diameter and length of the main root were about 0.3 cm and 1.5 cm, respectively. The transplanted test-tube plantlets have survived for six months in the lab and have normally grown in the field.

Production of Ginseng Matter and Distribution of its Assimilative Products

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The formation of ginseng output is dependent on luminous energy, carbon dioxide, water and the seasonal input of soil nutrient in the environment and the effiency of these energy and nutrient being transformed into economic valuble final products; obviously, the iater is more important. In order to know the physiological process of the transformative efficiency, we used the ^{14}C assimilative products of four years old ginseng in every main growing stage and the residual ratio of the main components in the root. By analysing the law of relative decreasing-increasing change of assimilative products being transformed into energy, structural matter and storing matter and the changing tendency of photosynthetic ^{14}C incorperating available components, the relationship of the accumulation of dry matter and the formation of available components at different growing stage had been shown, and supplied the theoretical basis for high output cultivation of ginseng. The results showed:

1. During different growing stage, assimilative products make different contribution to the formation of final products. The total residual ratio of assimilative products at seminal flower stage was about 54% in harvest ginseng, at red fruit stage, was raised by over 70%. The residual ratio of assimilative ^{14}C products being ranked in ginseng root at harvest time, assimilation at red fruit stage was the highest, next was at green fruit stage, last was at seminal flower stage. The accumulative ratio of assimulative products in the root at seminal flower stage only accounted for 28% of the total accumulative amounts of dry matter. Clearly the contribution from the assimilative products at later growing stage for the final products was more than from that at early growing stage.

2. The ratio of the assimilative products being transformed into energy, structural matter and storing matter was dependent on the assimilative stage. At early growing stage, specially at nutrient growing stage, 60% of assimilative products used as breathing hast and structural matter for the purpose of building ginseng trophozoite and ginseng successive growth so as to supply the carbon and energy sources, only less than 20% of assimilative products were transformed into storing matter and available components. The assimilative stage being lagged, the ratio of assimilative products being transformed into storing polysaccharide and available components obviously increased. Assimilation at red fruit stage, ^{14}C residual ratio of total saccharide, starch and total saponins in ginseng root were averagely 1~3 times as great as that at seminal stage. Obviously, the main physiological founction of the assimilative products as later growing stage had been transformed to store, form storing polysaccharide and available components in the root and supply the main sources for dry matter accumulation in ginseng root.

Research on the Mechanism of Energy Transmission on Photosynthesis, Enzymology and the Regularity of Light Needed in *Panax ginseng*

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Light is the only energy source of all kinds of creature on the earth. It acts as a very important role in controlling the growth of plants. Being a shade-plant, Ginseng like the light scattering and refracting rather than irrdiating straightly on it. This regulariry is complicated. Basing on the molecular structure of primitive preceeding reaction centure and the analysis of its spectrum, we suggest here a theoritical model on the energy transmission, and find a basic regularity of activities of several functional enzymes controlling by different light qualities and the regularity of light needed.

1. Light energy's transmission and utilization in photosynthesis.

In phtosynthesis, the absrobance and transmission of energy is finished in photosynthesis. Units

(PSU) which consisted by light harvesting chlorophyll (LHC) and reaction center (RC). From energy absorbed by LHC to charges seperated in central pigment molecules, the time is only 0.1～1.0 ns. There are three modles for energy transmission have been introduced: funnel, tree-pasts and pundle modles. And three are two ways to which the energy transmitted, resonance and exciton transmission.

With the increasing of light intensity, photosynthesis rate and its products will increase also. When the light intensity gets to a special value (Im), the photosynthesis rate will be the maximum (Gm) and do not change forever (this call light saturated point). We analyzed this theory and got the formula bellow which describing the relationship of Gm and Im

$$Im=\frac{37.5\times10^{23}\,Gm^{1/2}}{(1-n_1-n_2)}\int\frac{\varphi(w)}{W\Delta}m\ (w)\ dw$$

According to this formula, we have derived the another formula between the light transmissive rate of Ginseng film and Gm, Im.

2. Research on the ginseng enzymology and effects of light regulation.

For a long time, we have been studying on the activities of Nitroficase (NR). Amylase (Am), Peroxidase (POD) and Superoxide distumase (SOD) and we have got the regularities which changing with seasons. The result showed that, the activity of NR, POD, SOD in leaves is higher than in roots apperently, but the Am's activity in leaves is lower than in roots.

3. Research on the regularity of light needed in Ginseng growth.

Studies on Culture Physiology of *Panax ginseng*

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The characteristics of culture physiology pf *Panax ginseng* were studied with infrared CO_2 gas analyzer, ^{14}C plant photosynthetic rate analyzer, mass spectrometer and enzyme technology.

I. Characteristics of photosynthetic physiology

1. Ginseng is a kind of C_3 plant. Carbon isotope ratio ($\delta^{13}C$) and activity of phosphoenolpyruvate carboxylase were 26.80% and 14.33 U/mg prot min, respectively. The carbon dioxide compensation point changed from 80 to 102 ppm. The greatest true photosynthetic rate was 10.99 mg $CO_2/dm^2\cdot hr$.

2. Ginseng is a shade plant which needs strong illumination. Its light compensation point was 400 Lx; net photosynthetic rate increased rapidly under 400 Lx-10 kLx illumination, but increased slowly under 10～33 Lx. Its light saturation point was more than 33 kLx.

3. The highest total true photosynthetic rate and yearly total economic photosynthetic rate of either 4 or 5 year-old ginseng were measured among 2～6 year-old ginseng plants. The true photosynthetic rate was the highest from blooming to fruit greenning during a whole growth time, and from 9 to 15 o'clock during a day.

4. The leaves located in up, middle and low positions in the leave canopy had significant different true photosynthetic rates of 2.47, 1.45, 1.05 mg $CO_2/dm^2\cdot hr$, respectively. The true photosynthetic rate

of ginseng plants shaded with green plastic film was higher than that of those shaded with other colour plastic films.

5. The highest true photosynthetic rate of ginseng (4.3 mg $CO_2/dm^2 \cdot hr$) was measured under 80% relative moisture of soil during whole growth season and was advantageous to dry matter accumulation. The true photosynthetic rate of plant and dry matter accumulation of root decreased when the relative soil moisture was either 40% during whole growth season or less than 60% during postgrowth season or more than 80% during middle growth season.

II. Characteristics of Water Physiology in *Panax ginseng*

1. Transpiration efficiency of ginseng was relatively high (6.25 $g/m^2 \cdot h$) with lower transpiration coefficent (168) under the condition of 60% relative soil moisture during growth season.

2. Ginseng belongs to shade, mesophyte plant with drought sensitive and waterlogging sensitive. Water requirement in entire growth season was 135 kg/m^2, amount of evaporation was relatively high in both periods of flowering and emergence.

3. When the relative moisture of soil was 80%, root of ginseng grew normally with high biological yield and economic yield. When that was below 60% or reached 100%, the root became rotted or the fibrous roots became dry.

Effects of Gibberelin on the Physiological Dormancy of Ginseng Seed

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The seed of ginseng (*Panax ginseng* C. A. Meyer) had a long dormant period which was the one of the main difficulties in planting ginseng. Ginseng seed usually didn't germinate until it passed 21 months after sowing in natural condition. Some experts divided the dormancy into two stages, the morphological and physiological dormancy, the former needed warm stratification and the latter did cool. GA was usually used in ginseng seed treatment, but the effect meachism was not clear yet. So the research was about this point.

The seeds in physiological dormancy were analysed each week during the straification process, the analytical targets included the respiratory rate, the content of the total sugar and the uncleic acid (DNA and RNA), the activities of the peroxidase and the iso-citric acid lyase, the esterase-isoenzyme. The results indicated that GA made the dormant time shortened 3 weeks, with the respiratory rate, the esterase-isoenzyme and the peroxidase activities showing a better regularity than others. In contrasts to water treatment, the GA treatment made the respiratory rate increase fast, the new bands of the esterase-isoenzyme appear early and the peroxidase activities add obviously after 4 weeks. Those indicated that the respiratory rate level, the esterase-isoenzyme numbers and the peroxidase activities had a direct relationship with the seed's dormancy. So we concluded that GA's effects of breaking the dormancy were to stimulate the seed's respiratory enzyme and peroxidase activities rising, increase the protein synthetizing, thus made the dormancy broken earlier.

The Nitrogen Nutrition Characteristic of Jilin Ginseng

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In order to inquire into Jilin Ginseng requirtment law of N, experiments were carried out with External Source Nitrogen (ESN) 10 ppm was given and ^{15}N tracer method was used, surveyed 4~5 year ginseng utilization ratio to ESN, under ESN was varied to give levels (0, 10, 20, 30 and 40 ppm), use tracer method and chemistry analysis method to survey 4 years ginseng CO_2 assimilation ability, N reductase acitivity, ginseng root N, P, K. absorption, sugar, PN, NPN and saponin change. The results showed:

1. Before ginseng leaves extending period, 96%N came from the parent root. Afterwards, growth period 74%N came from the soil. For 4 years ginseng, annual period utilization ratio to ESN was about 9%, 4~5 years ginseng the two years total utilization ratio was about 19%.
2. Surveyed N reductase activity of 4 years ginseng leaves extending period, it was highest when ESN was 10 ppm.
3. When ESN was 10 ppm, ^{14}C distribution to ginseng root was 70%, higher than that of other treatment groups and the distribution to stem was about 7%, lower than that of other treatment groups. When ESN was 40 ppm, ^{14}C distribution to ginseng root was 61%, lower than that of control group, and the distribution to stem was higher than that of control group.
4. When ESN was increased, for 4 years ginseng, the relationship between ginseng stem, leaves DM weight and ESN was extremely significant positive correlation.
5. When ESN was 10 ppm, for 4 years ginseng, a single plant absorption N amount was higher than that of other treatment group. For 5 years ginseng in 20~30 ppm treatment group, a single plant absorption N amount was higher than that of other groups. ESN could promote the plants to absorb more P; When ESN was 10~20 ppm, the plant absorption K amounts was higher than that of control group.
6. ESN could increase PN and NPN content of the ginseng root, the first year, 10~20 ppm treatment group was the highest. The second years 20~30 ppm treatment group was the highest, 40 ppm treatment group NPN content was obviously lower than that of control group.
7. When ESN was higher than 30 ppm, the first year ginseng root total sugar, starch was higher than that of control group, total soluble sugar, saccharose and reducing sugar decreased. The second year, compared reducing sugar with that of control group, increased about 15%.
8. If ESN increased, the ginseng root C/N decreased, with 40 ppm treating, the first year C/N was lower than that of control group, the second year, each treatment group C/N had non-significant difference.
9. When ESN increased from 10 ppm to 30 ppm, the ginseng saponing content increased from 5.17% to 6.59%. But when ESN increased to 40 ppm, the ginseng root saponin content decreased to 4.97 %.

Effect of Temperatures on the After Ripening of American Ginseng Seed

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The process of after ripening of American ginseng seed could be divided into morphological stage and physiological stage. Further more, the morphological stage could be divided into embryo divison stage and rapid embryo growth stage. During the embryo growth stage, the cotyledon and radicle were divided from the immature embryo gradually. The embryo division would be passed when the accumulated temperature reached 1200～1300℃ with 1.4 mm embryo length. During the rapid embryo growth stage, the embryo growed by an average of 0.05 mm/day in length. The rate of seed dehisence reached the highest value when the accumulated temperature reached 1600～1700℃. The morphological stage of seed would be passed under the 1700～1800℃ accumulated temperature with 4.5 mm embryo length. The embryo growth would be slowed down when the temperature was raised from 10± 1℃ to 20± 1℃.

During the physiological stage of seed after ripening, the embryo growed 0.006 mm/day in length averaged with size enlarging. The seed was capable of germination after stratification for 50 days at 20℃ temperature. The longer seed stratificed, the faster the seed germinated with higher emergency rate. The seed would germinate if both days of stratification at 7℃ and stratification at 2℃ reached 88 days and the seed germination rate would be higher, but it would be lower if the seeds lost passing lower temperature.

Studies on Photosynthetic Characteristic at Dynamic Light Environment in Ginseng Leaves

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In order to understand the photosynthetic characteristic and photosynthetic production ability during the lightflecks in Ginseng leaves. Photosynthetic induction under continuous and fluctuating light conditions and CO_2 assimilation during the lightflecks were investigated in Ginseng leaves grown under high-light and low-light. The photosynthetic efficiency during lightflecks was also evaluated by comparing observed values of CO_2 gain at lightflecks with predicted values based on steady-state CO_2 assimilation.(a percentage between CO_2 assimilation during lightflecks and CO_2 assimilation under continuous light)

1. When Ginseng leaves were exposed to saturating light 450 $\mu Em^{-2}S^{-1}$) following a more than 2 hours in dark or at 20 $\mu Em^{2}S^{-1}$ low light, an induction period of 13～35 min were required before steady-state photosynthtic rate was attained. The time of induction state dropped to 20% of steady-state photosynthetic rate was 26～45 min. Ginseng leaves grown under low-light, the time of induction was shorter and the time of induction state loss was longer than those grown under high-light.

2. The ginseng leaves grown under high-light, the time course of photosynthetic induction and stomatal conductance induction were nearly same. But, the Ginseng leaves grown under low-light, the increase of photosynthetic rate was more fast than that of stomatal conductance during the induction. The changes of calcalated intercellular CO_2 concentration showed that the primary limitation to photosynthe-

sis during the induction was nonstomatal. The CO_2 assimilation was increased as the increase of lightfleck length, but photosynthetic efficiency was decreased. The shorter in lightfleck duration, the higher in lightflecks intensity. The higher in photosynthetic efficiency. The leaves grown under low-light had higher photosynthetic efficiency than those grown under high-light during the lightflecks.

Study on the Regularity of Accumulation and Distribution of Five Nutrients in Whole *Panax ginseng* Plant

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Former works have proved that some micronutrients, i.e., Cu, Zn, Fe, Mn and Mo, played an important role in the process of growth, development, nutrition and metalbolism for ginseng. The study on the regularity of uptake, accumulation and distribution of such micronutrients in ginseng can provide the scientific basis for nutritional status of ginseng growth in bed soil-micronutrient-ginseng system. A systematic interpretation about the accumulative and distributive regularities of every element in whole ginseng plant at age of 4 to 6 years is presented. The results showed that the accumulated amounts of the above five elements in ginseng organs changed regularly in different stages of growth. In roots, the accumulative curves of micronutrients show a tendency of decline and growth, and the turning points locate around the period of foliage expanding. Thereafter, the accumulated amounts increased gradually and reach their highest levels during the last stage of growth. In the process of growth, the micronutrients contents in leaves increase gradually, the peak accumulation value of each element appears at different stage of growth. The accumulation behavior of caudex and stalk are similar, the contents reach their climax in green or red seed period, respectively. In the whole growth period from foral initiation to seed maturation, the content of each element increase continuosly. As to plant with different ages, i.e., 4 to 6 year old, the regularities of accumulation are essentially the same though differing on amounts accumulated. The accumulated concentrations of micronutrients applied with N-P-K fertillizer increased considerably as compared with checkings.

To sum up, the micronutrient concentrations and micronutrient transportations within and between organs of ginseng plant differed markedly in different growth stages. During vegetative period, exuberant metabolic process occured in abovegroun tissues and micronutrients absorbed by roots were mainly transported to the aboveground organs. While till the late stage of growth the aboveground organs became semile, following the physiological activities weakened gradually, redistruibution of elements happened and a tendency of element translocations from the senile to permanent tissues was observed. Besides, this work also provided a scientific basis for appraising the nutritional characteristics of micrionutrients in ginseng and using trace element fertilizer in an optimum range in the process of ginseng cultivation, and budgeted initially the requisites for each element, in ginseng growth period, for forming perkilogram biomass.

Studies on Storing Method of Air-Dried Seeds of American Ginseng Before Stratification

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Freshly harvested seeds of American ginseng (*Panax quinquefolium* L.) were air-dried in a room for 35 days. The seeds were each stored in a refrigerator (3～4℃), in a cryostat (－15～18℃), in the room (12～18℃) and under a shed (natural alternating temperature), openly or sealdly for 255 days. Then the seeds were stratified for 135 days in the same condition. The seeds stored in the cryostat and in the shed putrefied. The seeds stored openly in the room lost moisture to 14.6%, whose putrefied rate were very high (reached 40%). But the seeds stored in the refrigerator and sealedly in the room were the best, whose putrefied rate was 0～3.3% and dehiscent rate was 73.3～93.3%.

Studies on Characteristics of Water Physilology in *Panax quinquefolium*

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Water is an essential matter and important condition for physiological and ecological water-requirement of *Panax quinquefolium* in its life activities. Revealing the characteristics of water physiology and the regularity of the water-requirement in *P. quinquefolium* can provide an important theoretical basis for scientifically planting *P. quinquefolium.* This experiment was carried out with three year-old plants in order to approach the water physiology of *P. quinquefolium.*

1. Effect of different soil moisture on yield of *P. quinquefolium.*

Our results showed that relative soil mositure at 80% in the whole growing period was advantageous to the growth of *P. quinquefolium*, displaying enlarged leaves, increaed fresh weight of aerial parts, high photosynthetic rate (4.31 $mgCO_2dm^{-2}h^{-1}$), rapid weight gain of roots, and high biological yield and high economic coefficient. The relative soil moisture at more than 80% (e.g., 100%) or less than 80% (e.g., 60～40%) was not advantageous to the growth of both aerial parts and roots, the biological yield and economic coefficient tended to lower and root weight reduced by 5～46%. The reduction range of the root weight (5～15%) in superwet soil (100%) was less than that (12～46%) in arid soil (60～40%), indicating that *P. quinquefolium* belongs to the hygrophilous plant. The different soil moisture had little effect on the length of the roots.

2. Effect of different soil moisture on inherent quality of *P. quinquefolium.*

When the soil was in superwet stress (relative moisture at 100%) or in arid stress (relative moisture at 100%) or in arid streess (relative moisture at 60～40%), the disease of roots tended to be serious state. The relative soil moisture at 60～80% was advantageous to the accumulation of total saponin. The content of the total saponin would reduce in the arid (40%) or superwet (100%) soil. The heat source substances of *P. quinquefolium* was not markedly afftected by water-supply condition.

3. Characteristics of water physiology of *P. quinquefolium.*

Our measurement results were as follows on condition that the relative soil moisture in the growing period was 80%. Transpiration intensity 7.83 g/h·m^2, transpiration coefficient 206, transpiration efficiency 5 and total water requirement in the whole growing period was 115 Kg/m^2 (44 plants). Amount of daily water evaporation and module of water requirement during different stages of *P. quinquefolium* were advanced, i.e. the maxiumm of the daily water evaporation (1130 ml/m^2) was at the blooming stage with little difference at other stages-seedling stage, fruit-bearing and root weight gain stage (about 800 ml/m^2), while the maximum of the module of the water requirement (34.23%) was at the seedling stage (47 days) and the minimum of the module (12.82) was at the blooming stage (13 days). That has provided scientific basis for reasonable irrigation.

Studies on Nutrient Physiology of *Panax quinquefolium* L. —I. Effects of Organic Fertilizers on Dry Matter Accumulation and Inherent Quality of Roots of *Panax quinquefolium*—

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The effects of applying four sorts of organic fertilizers, i.e. soybean cake, pig feces, deer feces and perillaseed, on the yield and quality of 3-year-old *Panax quinquefolium* plants were studied. Our results showed that the perillaseed (75~150 g/m^2) and deer feces (500~750 g/m^2) promoted the increase of total saponin and gross starch in the roots. As compared with CK, applying the perillaseed made the content of the total saponin and gross starch increase by an average of 0.35% and 2.23%, respectively, while applying the deer feces made the total saponin and gross starch increase by an average of 0.24% and 2.70%, respectively. Thus, it is advantageous to the quality improvement of the processed products of *P. quinqueforlium.* The soybean cake (100~150 g/m^2) and deer feces tended to increase the dry matter accumulation of roots, though their effects were not remarkable.

Zinc Deficiency of *Panax ginseng* and Its Control

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Panax ginseng is a perennial plant which absorbs relative large amount of zinc element during its life span. The zinc deficiency occurred frequently in ginseng production and decreased ginseng yield seriously. The foliar deficient symptoms of zinc mostly appeared from the leaf unfolding to blooming period and developed rapidly during the periods of fruit greening to fruit redening. The leaf symptom of Zn-deficiency did not occur or developed slowly after fruit reddening. As the age increased, the ginseng showed increasingly serious symptom of zinc-deficiency.

The ginseng foliar deficient symptom of zinc was characterized as an apparent of yellow-white spots which distributed evenly or unevenly on the leaf. As the symptom developed, the spots jointed together and the leaf folded, and further more, most of the leaf became chlorosis and lost physiological function. Zinc deficiency affected leaf photosynthesis of ginseng seriously. The leaf photosynthesis rate was only 1.689 mg $CO_2/dm^2 \cdot h$ which decreased by 48.3% than the normal ones. The rate of photosynthesis was increased by 16.46% after 3 days of spraying zinc at the leaf zinc deficiency.

The ginseng plant of zinc deficiency was short and small. On the average, the two-year old plant height, dry weight of air-part, main root length, and root dry weight were decreased by 13.5%, 40.42%, 35.9% and 35.96%, respectively as compared with those of normal plant. The three-year ginseng yield was reduced to 56.12% as compared with normal ginseng yield.

The major reason of ginseng Zn-deficiency was the short supply of effective zinc nutrient in the soil. The less the effective zinc content was, the more serious the ginseng Zn-deficiency was. Dense concentration of Ca and Mn could reduce ginseng to absorb Zn from soil. The concentration of zinc in ginseng root was negatively related to the effective concentrations of Ca ($r=-0.8928$) and Mn ($r=-0.6940$) in soil. It also was found that the ginseng symptom of Zn-deficiency could be worsen by largely applying phosphorous fertilizer in the zinc deficient soil.

The effective method to control ginseng Zn-deficiency was sparaying zinc sulphate at leaves at both stages of leaf unfolding and fruit greening. The sprayed concentration of zinc sulphate ranged from 0.2% to 0.5% and the relative control effect might be as high as 98%. The average root yield of three year-old ginseng was 1.8 kg/m^2 which was 63.64% higher than the yield of untreated plot in zinc deficifent plot, in the plot where zinc sulphate was spraied once a year and continually sprayed for two years.

Diagnosis for Some Element Deficiency Symptom of *Panax ginseng*

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Our experiments were conducted by using a direct liquid culture method of Hoagland modified nutrient solution and one-year-old ginseng (*Panax ginseng* C.A. Meyer) seedlings as culture materials. The pH of the nutrient solution was demarcated as 6.0± 0.1 and was changed once per 10～12 days. The culture was conducted indoors. Illumination intensity was controlled at 2000～8000 Lx and the nutrient solution was regularly aired by an oil-Less Gas Compressor. Ten treatments were designed in the experiment, i.e. complete solution (CK) and lack of Mg, of B, of Fe, of Mn, of S, of Cu, of C, and of Mo, with three repetitions. Our results are reported as follows.

Mg Deficiency. In the intitial stage, leaves began to change into red-brown along the edge of leaf tip and there was a deep red-brown pigmentation on the surface of leaf blade near vein. The pigment expanded towards the base of leaf, but the vein basically remained green. The setas on main vein also changed into red-brown. Finally, the whole leaf changed into red-brown but only the main vein remained green.

B Deficiency. The inter-veinal parts of leaf blade green-faded in slice, presenting a white and transparent hymenopterous stae, but the vein was normal. In the later stage the area of the white and transparent hymenopterous parts enlarged and there was a very slight red-brown pigmentation on the whole leaf and there was a mottled red-brown pigmentation on the petiole.

Zn Deficiency. Leaf was light-green and there were some yellow-white spots in the inter-veinal parts of leaf blade, but the vein was normal. The spot gradually enlarged and changed into brown. The edge of the leaf rolled up outward. In the later stage, the spots joined together as a whole piece and the whole leaf presented the mottled brown sports.

Fe Deficiency. The symptom of Fe deficiency was similar to that of Zn deficiency, having a light-green leaf. The vein was normal and there were some green-faded white spot pieces in the interveinal parts of leaf blade, but tiny vein was also normal. There was usually a purple-red pigmentation on the surface of leaf blade near vein. In the later stage, the inter-veinal parts of leaf blade presented the white hymenopterous state, but the state was not as serious as that in B deficiency.

Mn Deficiency. Leaf thinned and evenly green-faded and turned to white. In the later stage, the inter-veinal parts of leaf blade presented a white and transparent hymenopterous state that was serious in the center of leaf and slight in the edge of leaf. The vein was normal. There was an obvious purple pigmentation at near vein. A distinct demarcation line of green (veins)-purple (near veins)-white (inter-veinal parts of leaf blade) could be seen between the veins.

S. Deficiency. There was no symptom in the early stage. In the later stage, the purple-red pigmentation began with the tip of leaf, gradually expanded towards the base of leaf and rapidly spread all over the whole leaf. The setas were purple-red colour. The veins were green and, if the sympom was serious, also purple-red color.

Cu Deficiency. Leaf withering began with its tip. The withered parts were yellow-brown colour and gradually expanded towards the base of leaf. The veins also withered afterwards. There was a distinct demarcation line between the withered and non-withered parts. The green parts of leaf were normal. The withered part of leaf could account for a half whole leaf if the symptom was serious.

Ca Deficiency. The tip of leaf withered, rolled up inward and presented a water-scalded state. There was a distinct demarcation line between the withered and nonwithered parts. There was a transformation course from green to white in the withered parts in the early stage and the withered parts directly changed into white in the later stage. Once the symptom appeared, it rapidly developed. Some leaves withered from the edge of leaf to the inside of leaf, some directly withered from a certain position of leaf. The plants that are Ca deficiency had less absorptive roots, presented rust colour and had short, small and crooked roots.

Mo Deficiency. There was not any symptom.

CK plants grew normally.

The Embryogenesis and its Development of *Panax ginseng*

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The time course of the embryogenesis and its development of ginseng was calculated by the crossing method with artificial castrating, pollinating, bagging and sampling at fixed time. The plant materials were taken at 0.5, 1, 2, 3,···, 36 hours after pollination and once a day after 36 hours until the fruit ripening. The materials were fixed in either FAA or improved Nawaschin's fixation and then were cut into slices (10 μm thick) with paraffin method. The slices were dyed by iron-alum hematoxylin, then were observed and photographed under microscope.

The ginseng pollen could germinate on the stigma one hour after pollination. The pollen tube grew into embryo sac and released two sperms after 8~12 h. One of the sperms moved torwards egg cell and the other moved torward polar nucleus.

The sperm would combine with the egg nucleus after pollinating 12~24 h. The sperm chromatin dispersed in the egg nucleus. Male nucleous appeared after 2~3 h and the zygote was formed after 24 h. The dormant period of zygote was about 10 days. The first zygote mitosis occurred after 11 days of pollination and formed two-cell original embryo with pole. The top cell near the end of zygot was smaller with dense cytoplasm. The base cell near the micropyle has a big vacuole. The top cell and base cell divided crosswise to form four cells. Two of the new cells near the micropyle became strongly vacuolate while the other two cells which divided from the top cell still kept dense cytoplasm with little vacuole. Then the top two cells divided vertically and four-cell embryo was formed. At the same time, the cells near micropyle divided once or twice and formed suspensor with 3 or 4 cells. The four-cell embryo divided once and formed eight-cell embryo and further formed spherical embryo. At the early stage of the spherical embryo developing into heart-shaped embryo, two cotyledon primordia emerged ate the top of the embryo and multicell suspensor was formed. The young embryo would be 350~400 μm long when the fruit ripen. The cotyledon primordia were obvious and suspensor disappeared. There was no cotyledon, radicle, leaf and bud to be observed.

The combination of sperm and secondary cell nucleus were observed 12~18 h after pollination. The dormant stage of primary endosperm nucleus was 3~4 days. The first mitosis took place 5 days or so after pollination. 4~8 primary endosperm nuclei emerged in the thick protoplasm band and the quantity of endosperm nuclei increased as many as about 40 and cellularized gradually. The endosperm cells were full of embryo sac when the zygote developed into 2- or 4-cell embryo. The endosperm cells around the embryo disappeared and embryo cavity formed gradually 30 days after pollination. The cavity became evident after 40 days of pollination and the endosperm was plump. The ratio of embryo, endosperm was about 1 : 300 in size.

The time interval of embryogenesis and development discussed above was determined by the upper limit of the time when the images observed under microscope appeared at the highest frequency.

A Comparative Study on Tissue Cell of *Panax quinquefolium* Aged One to Four Years (I)

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The *Panax quinquefolium* L. was orginally produced in North America and was begun to be planted in China in 1975. At present, a wholly systematically scientific research is developing on the variety introduced and planted in 1975 and some cultivation research bases have been founded in this country. In this paper, the results of the comparison concerning some tissue morphologies (such as Periderm, Phloem, Cambium, Xylem and Substances contained in the cell, etc) of the *Panax quinquefolium's* root of the introduced variety aged one to four years were described. As the introduced one is growing up, the group of grain is getting more and more and its diameter become bigger, the number and ring of resin duct are on the increase and its diameter is getting bigger, and the colour of the secretion turns dark. As a result of its growing in years, each tissue morphology has changed in different degree.