Ginseng: Seed Germination and General Culture

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INTRODUCTION

American ginseng, *Panax quinquefolius*, was first discovered in Quebec, Canada in 1704 by Michael Sarrasin and was later rediscovered near Montreal, Canada in 1716 by a Jesuit missionary, Father Lafitau. Father Lafitau began searching for the plant after reading an article written by a Jesuit missionary in China which extolled the medicinal value of the Chinese ginseng, *P. ginseng*, and suggested that the plant might also occur on the North American continent. Samples of the root were sent to China for confirmation that it was the medicinal plant desired. By 1720 a company was formed to gather, dry, and ship the root to China. Gathering of the wild root continued through the years and by the mid-1800s had resulted in the decimation of wild ginseng in much of its natural range. By the beginning of the 20th century, several individuals were attempting to cultivate ginseng. One of the problems of successful ginseng cultivation involves seed germination, which requires up to 20 months under natural conditions.

American ginseng bears small greenish white flowers in an umbel. There may be well over 150 flowers in the umbels of cultivated ginseng, but seldom over 50 (commonly 7 to 30) flowers in the umbels of wild ginseng. The flowers are self-fertile and though they may be pollinated by several different insects, insect pollen transfer is not necessary (Carpenter and Cottam, 1982). Flower opening begins on the lower part of the umbel. Fertilized flowers develop berries which turn bright red in late summer or fall. Ripe berries may be found on the lower part of the umbel while unopened flowers may still be found at its center.

The fruit of ginseng is a drupe bearing 1 to 4 seed (pyrenes) and is composed of a fleshy sarcocarp surrounding a fibrous endocarp commonly called the seed husk. One gallon of randomly collected fruits from a commercial planting had seed per fruit distribution as follows: single seeded 16.3%, double seeded 77%, triple seeded 6.5%, and four seeded 0.2% (Stoltz and Garland, 1980). The weight of the seed decreased as more seed occurred in a fruit. Moist seed weight generally varied from 50 to 60 mg each with 8000 to 10,000 seed per pound. The seed measure 5 to 7 mm in length, 4 to 6 mm in height, and 2 to 3 mm thick. The embryo within the seed measures 0.4 to 0.5 mm in length and occupies a small gelatinous-filled cavity at the micropylar end of the seed. At the time the fruit ripens the embryo is in the heart or early torpedo stage of development. During an 18- to 20-month stratification period the embryo undergoes growth and development and at the time of germination is 4 to 6 mm in length.

The fibrous endocarp of the seed has a suture line which runs around its narrowest dimension. The seed can be opened by cutting along the suture line and prying it open to expose the endosperm which is enclosed in a thin tan to brown membrane. During stratification splitting of the husk along the suture line occurs 2 to 4 months prior to germination. Splitting of the husk allows the endosperm to swell and permits the developing embryo to actually grow longer than the original length of the intact seed.

HARVESTING

By late July or early August berries set on the lower part of the umbel will begin to ripen and turn red, while unopened flowers will still be present at the top of the umbel. For maximum seed harvests hand picking of the berries should begin when about half of the berries in the umbel have turned red. If picking is delayed the early ripening berries will be lost by falling on to the bed. Two or three pickings are necessary. Pink and green berries have seed which are not adequately developed and should not be picked.

CLEANING

Two methods are commonly used to separate the berry skin and pulp from the ginseng seed. Mechanical macerators break the skin and float the skins and pulp away in a flow of water. A batch of seed can be cleaned in 10 to 20 min by these machines. After cleaning the seed should be floated to remove light seed.

A more common method is to place the berries in a burlap bag and trample the bag to mash the berries and start fermentation of the pulp. A force of water from a hose is used to wash the pulp through the bag. The bag should be trampled, hosed, and turned over at least once each day for 7 to 10 days. Finally the seed are removed from the bag and placed in buckets to float off the skins, remaining pulp, and light seed. The seed must be kept moist at all times; if the seed are allowed to dry at any stage from harvesting to germination their percent germination will be reduced. The macerator gives a much cleaner seed than does the fermentation process (Polczinski, 1982).

TREATMENTS BEFORE STRATIFICATION

After the seed are cleaned and floated they are commonly treated with formaldehyde diluted with water (1 : 85, v/v) for 1 h, Clorox diluted with water (1 : 9, v/v) for 10 to 20 min, or the seed may be dipped in a fungicide slurry such as Captan, Ridomil, Topsin, etc. before being placed in the stratification medium. Some growers do not treat the seed prior to placing them into stratification.

STRATIFICATION

Stratification boxes are constructed with a wire screen on the bottom and top to protect the seed from rodents and to allow water to readily penetrate the mixture. The boxes are placed in pits with gravel at the bottom for drainage or they may be placed on top of the ground and mounded over with soil. There should be a minimum of 4 in. of soil on the top and 12 in. of soil on the sides. In the spring, some growers remove the boxes and refloat the seed to remove any which have rotted or have precociously germinated. The seed are restratified until September when they are lifted and sown into prepared beds.

One grower was using naked stratification of the seed in fiber drums kept in an unheated workroom where he could keep the winter temperature from going below freezing. The drums were opened frequently to check moisture content and then placed on their sides and rolled to stir up the seed, to provide better aeration throughout the drum.

FUNGICIDE TEST

Poor seed germination is frequently encountered. Soil pathogens often contribute to

a low seedling stand. A test to determine if fungicides would increase seedling stands was done using seven fungicides. All treatments were applied at 1.5 oz of product for 25 lbs of seed and the seed sown into an outdoor shade bed previously fumigated with methylbromide. The seed were sown at 1-, 2-, and 3-in. spacing in rows 6 in. apart. The percent germination was recorded in June and the plants were harvested and weighed at the end of the first growing season to obtain root weights. The materials used and the results are presented in Table 1. None of the treatments resulted in significant increases in seed germination or root weight. However, Bayleton significantly decreased plant stand and may be phytotoxic to ginseng seedlings.

Table 1. Average percent germination and average root weight resulting from seven different fungicide treatments.

	Average germination (%)[y]			Average root weight (g)		
	Seed spacing in inches					
Treatment	1	2	3	1	2	3
Untreated	77.8 a[z]	61.1 a	75.0 ab	0.52 b	0.90 a	0.73 a
Benlate 50W	77.8 a	76.4 a	87.5 a	0.78 ab	0.94 a	0.78 a
Dithane M-45 80W	76.4 a	86.1 a	45.8 b	0.78 ab	0.91 a	0.82 a
Vitavax 200	71.5 a	81.9 a	69.2 ab	0.76 ab	0.93 a	0.67 a
Topsin M 70W	70.8 a	79.0 a	90.0 a	0.74 ab	0.95 a	0.82 a
Ridomil 2E	70.1 a	76.4 a	77.5 ab	0.82 a	0.70 a	0.73 a
Bay NTN 19701 25WP	59.0 a	81.9 a	70.8 ab	0.65 ab	0.91 a	0.67 a
Bayleton 50W	28.5 b	19.4 b	15.0 c	0.69 ab	0.94 a	0.00 b

[y] Average of three 36-in. rows.
[z] Values in a column followed by the same letter are not significantly different (DMRT, P=.05).

WATER ABSORPTION

The fibrous tissue of the seed husk poses no restriction to water absorption or the passage of dissolved chemical compounds at least up to the molecular size and configuration of aniline blue dye. Seed placed in an aniline blue water solution, withdrawn at 1-min intervals and cut open to observe staining on the inner surface of the husks showed some staining at 1 min and moderate to heavy staining in 10 to 20 min. However, no dye was observed to pass the thin membrane which covers the endosperm tissue even after 40 h of soaking in the dye solution. These results indicated that gibberellic acid (GA_3) in solution should readily penetrate the seed husk.

GIBBERELLIC ACID TREATMENT

Gibberellic acid has been reported to be effective in stimulating embryo growth of freshly harvested Chinese ginseng seed (Choi, 1977; Grusvickij, 1965; Varob'eva

and Gutnikova, 1967) but had no effect on germination. Gibberellic-acid-treated seed stratified for 165 days at 15C also showed no significant increase in percent germination (Choi, 1977).

Two groups of freshly harvested American ginseng seed from (1) cultivated northern plants and (2) wild Kentucky native plants were treated with 0, 500, 1000, 2000, and 5000 ppm GA_3 for 16 h and stratified in moist sand at a constant 20C. Ten embryos from each treatment were measured monthly for 19 months. Most elongation of the embryo of the treated seed had occurred by 4 months; embryos of treated seed were longer than those of untreated seed at every measurement interval.

In a separate test four lots of 50 seed each were left untreated or placed in either water or 1000 ppm GA_3 and aerated for 24, 48, or 72 h. The seed were stratified in moist sand at 5C for 5.5 months and then examined for seed splitting or germination. Gibberellic acid treatment resulted in a significant increase in splitting of the seed husk (Table 2). The average seed husk splitting for GA_3 treatments was 60% vs. 1% for water-aerated seed. The endosperm of many of the GA_3-treated seed were swollen to 150% the size of the seed husk. Examination of these seed showed that the center of the endosperm tissue had been liquified but the embryos were still less than 1 mm in length. The seed were planted in sterile soil, and placed on a greenhouse bench at 22C day temperature. After 5 months, no germination was observed and most seed had rotted.

Table 2. Percent seed showing no change, splitting of seed husk,or germination as a result of aeration in water or 1000 GA for 24, 48, or 72 h.

	Treatment						
	H_2O			1000 ppm GA			Untreated
Seed condition	24	48	72	24	48	72	
No change	97.5	99.0	98.5	55.5	27.0	35.0	99.5
Splitting of seed husk	2.5	1.0	1.5	42.5	73.0	65.0	0.5
Germination	0.0	0.0	0.0	2.0	0.0	0.0	0.0

WATER CONTENT OF STRATIFICATION MEDIUM

Forty-two lots of 110 ginseng seed each were stratified in 100 g of dry sand to which was added 0, 5, 10, 15, 20, or 30 g of water; seven lots for each moisture level. This was done in September. Each month one lot from each moisture level was selected. From each lot 10 seed were randomly selected to determine seed dry weight, fresh weight, and percent moisture content. The embryos of the remaining 100 seed were measured. The seed were held at 20C until over 50% of the embryos were 1.5 mm in length and then transferred to 5C (this occurred in Jan.). I am of the opinion that the embryo of the seed must be about 2.5 mm in length to receive the stimulus of the second cold period for germination to occur.

The results indicate that a stratification medium moisture content between 10% and 20% is best. No moisture, as expected, eventually killed the seed and at 30%

moisture, oxygen availability to the seed was probably limited and prevented embryo development; 5% moisture is considered somewhat detrimental. For all seed with moisture supplied the percent moisture content of the seed varied between 38% and 43% at all measurement times.

LEACHING TEST

American ginseng seed stratified outdoors have minimal growth of the embryo for the first 7 to 8 months (Stoltz and Snyder, 1985). Such restriction of embryo growth indicated that an inhibitor might be present in the seed which is eliminated during this period. After elimination of the inhibitor (probably by natural leaching) and warm soil temperatures are encountered the embryo begins to elongate. Lee, et al., (1983) have reported that sodium hydroxide seed treatment may have eliminated an inhibitor and promoted embryo growth. Choi and Takahasi (1977) have reported inhibitors in the sarcocarp, endocarp, and endosperm of *P. ginseng*.

Table 3. Average embryo length as affected by leaching in running tap water for various time periods.

Temp. held at °C	Date measured	Embryo lengths in mm: Days of leaching 0	4	8	12	16	20	25
20	Sept. 84	----------	----------	----------	0.53	----------	----------	----------
5	Dec.	1.50[z]	1.63	1.60	1.63	1.66	1.49	1.77
	Feb. 85	2.0	2.01	2.09	2.08	2.14	2.14	2.60
	Apr.	2.31	2.44	2.76	2.96	2.80	2.24	2.38
20	June	3.22	2.55	2.91	3.25	2.50	3.20	3.40
	July	2.52	2.77	3.00	2.87	2.84	2.81	3.21
	Sept.	2.86	2.72	2.83	3.03	3.10	3.79	3.00
5	Nov.	2.61	2.87	3.26	3.74	2.94	3.73	3.29
	Feb. 86	3.01	3.29	3.72	3.75	3.38	3.61	3.49

[z] Statistical analysis showed no significance among days of leaching.

To determine if leaching of ginseng seed would stimulate embryo development and give early germination, 50 g lots of fresh seed were leached in running tap water for 0, 4, 8, 12, 16, 20, and 25 days. After leaching the seed were stratified in moist sand and held at 20C for 3 months, 5C for 5 months, 20C for 6 months, and finally 5C for the remaining time. Ten seed were removed from each lot at various times and the average embryo length was determined (Table 3). Embryo growth does not appear to be benefitted by leaching.

PRECOCIOUS GERMINATION

Precocious germination, which is considered to be a problem by growers, should be viewed as having a potential benefit. Seed germinating the first spring should be selected out and planted into a separate area for subsequent seed production. Once this is done, two approaches are possible. Ideally, each resulting plant could be numbered and the seed identified as to parent source. Parent plants which produce higher percentages of seed with precocious germination can be selected for continued seed production and their progeny also planted into source identifiable plots for further selection. The second approach involves essentially the same procedure except the seed are not identified as to the parent plant source but each succeeding generation of precociously germinating seed would be planted into identifiable plots for seed production. By either method, selection for precocious germination should result in seed crops which have high percentage germination in the first spring after seed ripening.

SUMMARY

The embryo of American ginseng seed must equal or exceed 50% of the length of the seed before it can be induced to germinate; this would translate to an average embryo size of 3 mm in length. Treatment with GA_3 and stratification at 20C for 3 months can accomplish this objective. A second necessary part of ginseng seed germination appears to be a cold requirement after the embryo has attained a certain minimal size.

The treatment of seed with fungicides prior to seeding did not show any significant advantage to fungicide treatment. However, these seedings were planted into soil previously gassed with methyl bromide. If seedings are planted into untreated soil, fungicide treatments are a good insurance against early disease losses. Any of the fungicides used in these tests, except Bayleton, could be used.

Although inhibitors are reported to occur in both the fruit and seed of ginseng, leaching in running water did not improve the rate of development of the embryo. It is possible that the inhibitor is still present (i.e., not leachable) and its effect is not restrictive of embryo development but rather acts to keep the radicle from growing until the embryo has attained a critical size. Some preliminary work I have done indicates this possibility.

Finally I believe the concept of precocious germination should be utilized to begin selecting for strains of American ginseng that will germinate the first spring after seed ripening.

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