Wild Simulant Production Methods for American Ginseng Farms in Tennessee

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Introduction

Asian ginseng (*Panax ginseng*) is a fleshy root plant that has been used for millennia in Asian medicines[1-6]. American ginseng, or *Panax quinquefolius*, is the North American cousin to Asian species and both are members of the ivy family. Both the Asian and American species have been valued throughout history,[1,7,8,17] and collected or cultivated for use. Overseas sales records date back to colonial times in the United States[7,8,17]. These sales have led to a change in the natural growing range of the plant[7,8,13]. The three most prolific producers for consumption as of 2014 are China, the Korean Peninsula and North America[1].

The demand for ginseng is highest in the Eastern markets. Historically, this is due to the plant's heavy use in traditional medicine[13,14,17]. The root is believed to promote general health and is often prepared for use in a wide variety of treatments[13,14]. The West has traditionally been more skeptical about health claims involving traditional medicines, however researchers have been analyzing compounds produced by the plant and investigating how those chemicals affect the human immune system[13,14,17,18]. Research into these effects is also generating more demand, due to the promise for possible health benefits that have been demonstrated. Because of both the traditional markets and newer markets opening up, demand is continuing to expand.

The plant produces a distinctive white taproot that oftentimes branches and takes a shape that has been described as "humanlike" in form. As a perennial herbaceous plant, the root grows from year to year, increasing in size and developing a darker color as time passes. The above-ground portion of the plant dies back each season, only to grow again during the spring and summer months. It is a slow growing,[1,9] shade-loving plant that normally can take anywhere from 3 to 7 years to mature to commercial viability[7,8]. The long lag time has led to many attempts to refine the agricultural production of the product[1-6,9]. This extended production time in agricultural models, plus the high market price that quality specimens can achieve, has led to a decline of wild samples due to poaching,[1,7,8] which in turn has led to regulations involving its harvest and sale[8]. The reason for the illegal trade is that traditional cultivation methods can be more costly[9] than simply poaching the plant and demand for wild product is exceptionally high[1,8]. As the main market for consumption is still the far east, with China having a tradition of its use for thousands of years,[1,13] the desire for this product is in no way abating any time soon.

To meet this demand, both farmers and wild ginseng harvesters have stepped up output to leverage a growing far-eastern economy. Agricultural scientists have been researching methods to aid farmers in their production. Studies have been performed to see the effects of different production and processing methods on the chemical compounds produced by the plant and the market value of agriculturally produced roots[2-6,9,11].

The goals of this paper are (1) to summarize the research of several specialists into one coherent narrative; and (2) to give agricultural producers a working understanding of several variables that affect the growth and value of North American ginseng. Of the production models in use by agricultural producers, namely intensive, hydroponics/aeroponics, and wild simulant, this paper focuses on the wild simulant model. Several of the key factors that affect wild simulant production methods also play a role in the other production models. By focusing on this one production method, information from a diverse set of disciplines can be delivered to the public in a fashion that allows for its practical use.

Site Requirements

American ginseng is a shade-loving plant, and its preferred habitat reflects that[12,14,15]. Locations with full shade, in deciduous hardwood forests[12,14,15] are typically the best choices for sites when employing the wild simulant method of production. Ginseng is a plant that naturally grows in established hardwood forests, with trees that have deep roots[15,17]. Deep-rooted trees will compete less for water with ginseng plants than shallow-rooted trees, while still providing cover. In addition to the light filtering, the trees deciduous nature will also give the added benefit of seasonal mulching due to leaf drop[19]. Hilly areas with slight to moderate slope will allow for good drainage, another positive trait for the site. Since there is little tillage required in wild simulant production, slope will not be as difficult a problem as it would be for crops requiring a row cropping method. Soil types that are favored by the plant are typically loamy, well drained, moist with high organic matter[15-17]. Southern or western facing slopes can be problematic if in low elevations due to temperature differences, however at higher elevations this is less problematic[15,16,17].

Soil Sampling

Soil samples should be taken from possible sites, with soil composition (sand, silt, clay ratios) soil chemistry, organic matter levels and nematode infestation levels all being key areas for attention[15-18]. These factors can be determined by submitting soil samples for analysis, a service that can be obtained by contacting your local agriculture extension agent and department of agriculture. Recent developments in the market indicate that buyers are also paying attention to pesticide residue levels in ginseng roots. Any past use of long lasting pesticides in the area, specifically DDT for example, should be taken into account as well when deciding plot location. This is due to the possibility that the plants will uptake the pesticide and would, therefore, be considered less attractive to the market. Site history, therefore, is also valuable, so that the farmer will be aware of any possible long term residues built up in the environment.

Soil Chemistry

In this instance soil chemistry refers to two traits, chemical nutrition and soil pH. While many are aware that plants require nitrogen, phosphorus and potassium for growth, there are many nutrients necessary for plant health and development. Some of these nutrients, like nitrogen, phosphorus and potassium are known as macronutrients, while others like copper, molybdenum and zinc are known as micronutrients. Macronutrients are needed in large quantities by the plant and, therefore, are often the basis of many fertilizer mixes. Micronutrients are needed by plants as well; however the amounts required are vastly less. Both micronutrients and macronutrients are required for healthy biological function. Because of this difference in consumption, it is rarer to amend the soil by adding micronutrients than amending the soil by adding macronutrients, as macronutrients are often exhausted faster in commercial production than micronutrients.

Phosphorus and Calcium Levels

Two macronutrients whose levels have been shown to have an impact on ginseng quality are phosphorus and calcium[15-17,19]. Soil studies performed in both New York and in East Tennessee[16,20] showed calcium deficiencies led to stunted growth, and sites that had higher concentrations of calcium produced healthier, better quality plants[16,20]. Calcium levels around 4000 lbs of availability per acre and phosphorus levels of at least 95 lbs availability per acre are advised to improve plant health[16,17,20]. One should also take care to apply a calcium fertilizer that does not adversely affect the pH levels of the soil in the region. *To avoid raising the pH of the soil* it is recommended to use calcium sulphate, commonly called gypsum, instead of calcium carbonate, commonly called lime[16]. This is due to the chemical reactions resulting from adding lime to the soil, raising pH levels.

Ginseng has been shown to grow in a wide range of pH levels in the soil, but traditionally, growers have been advised pH values near 5 to 6[15-17,19,20] should be sought. Ginseng production has been shown to be optimal at these pH levels [15-17,19,20]. There are many reasons that this could be the case. Acidic soils may suppress certain pathogens and diseases[16]. Soil acidity also affects micronutrient availability. Micronutrients are often abundant enough already in the soil as to make it unnecessary to add more. However, soil pH does affect nutrient availability, making some nutrients less available for uptake by the plant. This is because the pH can affect the soil's ability to release the nutrients in a form that the plant can absorb. Therefore, if the soil pH is too high or too low, plants can suffer from micronutrient deficiencies, which can lead to stunting and dieback. As studies have shown that pH levels of 5 to 6[15-17,19,20] produce healthy ginseng plants, it can be surmised that these pH levels are the optimum for micronutrient uptake by the plant.

Scouting Locations via Plant Populations

When scouting areas for ginseng production, one can inspect the plants that are growing at the site already, to see if the conditions are conducive to growing ginseng. If plants that favor the conditions that ginseng prefer are present, then the chances that the site is advantageous for ginseng production are greater. There are several species of plants that share the range of ginseng and favor similar site characteristics[16,21]. Being able to identify these plants, therefore, will aid a farmer wishing to determine which sites are likely the best candidates for ginseng production. The following plants are good indicators of a site's viability for ginseng growth[16,21].

Common Name	**Scientific Name**
Bloodroot	*Sanguinaria canadensis L.*
Solomon's seal	*Polygonatum biflorum*
Jewel weed	*Impatiens capensis Meerb.*

Galax	*Galax urceolata*
Trillium	*Trillium pusillum*
Wild yam	*Dioscorea villosa L.*
Hepatica	*Hepatica nobilis Schreb.*
Black cohosh	*Actaea racemosa L.*
Wild ginger	*Asarum canadense L.*
Mayapple	*Podophyllum peltatum L.*
Spikenard	*Aralia racemosa L.*
Ferns	*Varies*

The USDA has extensive information on their website, with a searchable database for public use (http://plants.usda.gov/java/). See the appendix for more information, links and images have been provided for producers' use. One note should be made about scouting locations with ferns. Ferns produce compounds called allelochemicals. Allelochemicals are compounds produced by organisms to protect themselves. Think of them as chemical warfare, weeding out competitors for resources like light, nutrients and water. Since allelochemicals suppress the growth of competitors, and for the fern, ginseng is a competitor, an overabundance of ferns can suppress ginseng growth[15,16,18]. Small quantities can be worked around, but a large concentration of ferns should be avoided.

Seed Considerations

The American ginseng plant produces white flowers in the summer[14], which will produce a cluster of green fruits after germination. As the fruit ripens, it will take on a red color[14]. Each fruit will contain one to three seeds, however they are not stratified. As with several plants, the seeds of American ginseng have to go through a period of dormancy before they will grow. During this dormant period, the seed must be exposed to some form of stimuli to begin the processes that allow for germination and growth. For American ginseng, seeds must overwinter and be exposed to cold temperatures for at least a season before they will be able to germinate. This period of dormancy can last for one or more seasons, therefore it is in a farmer's best interest to always purchase stratified seeds from reputable seed sources. Contacting a local ginseng cooperative is an excellent source for information on vendors. In the wild simulated model for ginseng production, plants will be allowed to reseed the bed, however due to natural thinning, predation, and harvest, a farmer should plant new plots to help replace the ones that will be harvested[16].

Purchasing Seed

Seeds can be purchased typically between July and August[16], with regions having differences in when seed can be sold. Specific dates of availability in your region can be obtained by contacting your local ginseng cooperatives or your local department of agriculture agents. As the process of stratification requires care and attention, try to avoid seed whose price seems "too good to be true", as it probably is. Some distributors have been known to sell non-stratified seed as stratified, so again, contacting your ginseng cooperative is a good idea for purchasing seed. Purchased seed should also be stored in a refrigerator until planted[16]. The reason for this goes back to the concept of stratification and the stimuli that were discussed earlier. Seeds left out at room temperature could germinate early, or dry out. Both scenarios would ruin seed before it gets into the ground.

Testing Seed Viability

Even the most careful and honest farmer, however, cannot guarantee that 100% of the seeds he is selling will germinate. Due to biology, time, and sometimes random chance, some seed will not be viable. Seed also can go bad in storage. To maximize germination rates, it is considered wise to test seeds for viability before planting them. The fastest way to test viability is to perform a float test[16]. A float test for seeds is when the seeds are placed into water to see if they sink. Seeds that are more likely viable will be heavier, and will sink. If a seed is too light, it is more likely not viable[16]. The lighter seeds will float, which is a sign one should not plant them. When seeds are placed in water, one should discard the floating ones.

Another reason to perform the float test is so that one can perform two steps of the planting process at once. Those two steps are first to weed out any seeds that are less likely to germinate and, second, to process them in a manner to lessen the chance of fungal contamination. Almost all purchased seeds will be contaminated with several pathogen fungi. This is due to the prevalence and hardiness of the fungal spores in nature. Therefore, it is wise to treat the seeds before planting, to minimize the chance of inoculating beds with fungal contamination.

Treating Seeds to Prevent Fungal Contamination from Seed Source

The following anti-fungal treatment[16] should be performed on seeds before planting. The seeds should be soaked in 10% bleach solution for 2 minutes. After 2 minutes, the seeds should be thoroughly rinsed in clean water. To achieve a 10% bleach solution one should put one part bleach for nine parts water. While this will not get rid of all of the fungal spores, exposure to bleach will greatly reduce fungal contamination.

So to combine the steps of washing the seeds to lessen fungal growth and testing seed viability one can do the following. First, wash the seeds in bleach like previously described. Then dump the seeds in clean water and rinse off the bleach thoroughly as previously described. Any seeds that float should be discarded during the rinse stage.

Another question farmers have pertaining to seed is how much seed is needed for a given amount of acreage. When starting, a farmer will need approximately 10 pounds of seed per one half acre of wild simulated plantings[16].

Site Preparation

Once the site is chosen, and the seeds are prepared, site preparation can commence. It is recommended to use stakes and twine to keep track of bed outlines without permanently marking the area. In the wild simulated model of production, there is much less tilling and fungicidal applications, as the model attempts to simulate the conditions the plant would experience in nature. Planting should occur in the fall after leaf drop[14-17,19,20]. Beds should be five feet wide and fifty feet long[14].

Ferns

Make sure to avoid large patches of ferns due to allelochemical production by the ferns, which can stunt plant growth. Allelochemicals are compounds made by plants to drive away competition. If you have ever seen bald spots under sugar maples, or black walnuts typically these are due to the trees producing chemicals to drive off competition. Ferns also use this strategy, that is to say they too produce compounds to kill off competition for water and soil nutrients. That is why you should try not to plant near large concentrations of ferns and clear out any that seem to be encroaching on your planting site. Other than ferns, one should not worry too much about clearing the underbrush of plants. In wild simulant models, many plants are left as they are. This is for two reasons: (1) the interactions between the plants are more in line with the conditions that a wild sample would experience and; (2) by limiting the amount of disturbance to the soil, one lessens the likelihood of fungal pathogens gaining a foothold in the bed. Biodiversity applies a downward pressure on pathogenic species; therefore, leaving a diverse set of plants will lead to less need for pesticides.

Bed orientation and Prepping

The beds should be oriented to run up and down the slope instead of perpendicular to the slope[16]. This orientation will help with drainage, and this should help suppress fungal growth by improving water and air flow through the site. Leaf debris should be raked off the beds, clearing the work area. Do not discard the leaf debris, as it will be used to recover the seeds after planting. Make three narrow furrows eighteen inches apart the length of the bed. Plant seeds three inches apart in these furrows[16]. Cover the seeds with 3/4 inch of topsoil from the site, and rake the leaf litter back onto the beds. Compress the soil by stepping it down[16]. The leaf litter will act as mulch. Each five foot by fifty foot bed should use an ounce of seed[16], so if one scouts the sites beforehand, this rate can be used to determine the needed seed quantities. Once the seed is applied, and the soil and leaf litter is covering it, one can apply fertilizer if needed. Fertilizer should only be used if the soil analysis indicates. For instance, if calcium levels are low, or if phosphorus levels are low, the soil should be amended.

Amending Soils

Nutrients can be added by spreading the appropriate amounts of fertilizer on the topsoil. Fertilizers are labeled with the percentages of nutrients available. To find out how much a pound of fertilizer contains of the nutrient in question do the following[22]:

1 pound of fertilizer X percentage of nutrient listed = nutrient per pound of fertilizer.

So for instance, one has 100 pounds of triple super phosphate. The listing on triple super phosphate is as follows, 0 -46-0. So the 100 pounds of fertilizer has:

100 pounds of fertilizer X 0.46 = 46 pounds of phosphate.

That means for each one pound of fertilizer applied, 0.46 pounds of phosphate are added to the soil. This formula is used to calculate how many pounds of fertilizer to apply to a site to achieve the appropriate nutrient amendments. The following equation can be used to calculate the amount of fertilizer needed to be applied to a given area[22]:

(Required rate per area / % of nutrient in the fertilizer) X area = amount needed for area.

Continuing the example, assume the soil analysis has stated the site has, on average, 50 pounds of phosphate per acre and the amount one wishes is 95 pounds of phosphate per acre. The area to apply this amendment is one acre of land. First see what the deficit is:

95 pounds per acre (desired) – 50 pounds per acre (current) = 45 pounds per acre required.

Therefore:

[45 pounds per acre (required rate per area) / 0.46 (% of phosphate in the fertilizer)] X 1 acre (area) =

97.82 pounds of fertilizer per acre are required.

These calculations work for determining the amount of the fertilizer that is needed to be added. Depending on the report, soil analysis tests can either come back with a recommended amount of fertilizer to add, like phosphate, or a recommended amount of elemental nutrient to add, like phosphorous. If the results are formatted for elemental nutrient levels, one can convert the fertilizer percentage on the package to the amount of elemental nutrients and then use that value to determine the amount of fertilizer to add to achieve the nutrient levels. See Appendix II, *Calculating Elemental Compound Ratios from Fertilizer Formulations,* for further discussion.

Yearly Benchmarks

Due to the botanical nature of the product in question, a producer can look to certain signs to monitor the development of his ginseng crop. One can then take certain measures to insure a steady stream of production, by making sure the crop is receiving the appropriate treatments required at each developmental stage. This information can be used to gauge when to harvest or treat beds. The following are several key biological signals useful to a farmer. The plant is a perennial, however the stem and leaves die back each year[14,17,19]. The root is the portion of the plant that lives season to season, increasing in size. The seasonal regrowth of tissue leaves behind indicators that can be used to track maturity levels of the plants.

There are two ways to visually gauge the age of a plant. During the summer, one can inspect the foliage, while during the fall one can inspect the collar scar[14,19]. As the plant gets older, the stems have a tendency to produce more leaves and larger leaves, with more prongs. The following leaf progression can be used to determine age[17,19]:

First year seedlings are trifoliate

Second year plants have one prong

Third to Sixth year plants have two prongs

Seven to Nine year plants typically have three prongs

Ten to Eleven year plants should have four prongs

One to two year-old plants can have stems and leaves four to seven inches in height[14,19]. As the plants mature, bush sizes can increase, and reach two feet. As the plant ages, the root continues to increase in size. The size of the stems and leaves can be an indicator of the size of the root, as ginseng plants with larger roots typically produce larger foliage and stems. Stem height, therefore, can be used to gauge which roots in a bed typically are larger than others.

When the stems die back in the fall, they leave behind a collar scar, which is a ring-like scar on the root collar. Similar to a tree, the number of rings can be used to assess the age of the root. This gives the farmer a tool for determining age without relying on foliage development or size.

At three to five years, the ginseng plants will begin producing berries[14-17,19,21]. These berries will be green during the summer, eventually turning red. In each berry, there will be one to three seeds. If the plants are left to their own devices, these berries can reseed the bed. That being the case, if the farmer is wishing to insure that each season will produce more ginseng than is harvested, a regimen of replanting to replace what was harvested will need to be in place[16,19]. Checking calcium levels, alongside other nutrients, will help to determine when to fertilize so as to avoid exhausting the soil.

Also, as beds mature, pressures from the environment and natural processes will cause the ginseng to self-thin. This process is to be expected, and the planting regimen takes this fact into account. The self-thinning results from predation from animals, competition for nutrients and water and natural losses due to disease or weather stress. One should not be surprised, therefore, if beds thin as time progresses. The remaining plants will develop and take a more wild appearance over time.

Pests, Threats, and Mitigation

Pests and threats for ginseng production come in four categories: (1) fungal, (2) insectoid, (3) mammalian and (4) human action. Through proper planning and preparation, the risks these factors pose to production can be mitigated, but not eliminated. Because no system can economically eliminate all risk, the goal is to design a system where the cost of prevention does not outweigh the savings it produces.

With the wild simulated model, biodiversity is conserved. That is to say, instead of having a system in which you have a densely packed monoculture population in an area, you have a diverse set of organisms. The advantage of monoculture is an ease of producing large amounts of a crop. The disadvantage of monocultures is that they are susceptible to widespread pathogen outbreaks. This is one of the reasons why farmers must be very careful when producing monoculture crops, because once a disease or predator gets into a monoculture, its population can explode unchecked.

Ginseng does not have many ginseng-specific pathogens. Disease pathogens common to ginseng production are Phytophthora[16], Rhizoctonia[15], Fusarium[15], Pythium[15], and botrytis blight[15]. All of these can cause damping off and dieback. All of them are more common in intensive production versus wild simulated production however. While fungicides can be deployed[14-16,21] to mitigate fungal problems, there are cultural practices a farmer can employ to limit the need to use pesticides.

Cultural Practices to Limit Fungal Growth

Fungal diseases thrive in tightly packed areas with little drainage and low air flow[15,16]. Making sure to plant beds in loamy moist, but well-draining soil, and running up and down with the slope instead of perpendicular will allow for better drainage and air flow. The lack of intensive tilling disturbs the soil less, giving fewer opportunities for fungal spores to be spread. Also the lack of intensive tilling disturbs the beneficial microbes in the soil less. Beds spread out over an area, insures against a single infection wiping out the entire crop[15,16]. The biodiversity and the compartmentalized design of the beds will make it more difficult for a single infection, predator or thief to wipe out the crop.

Antifungal pretreatment of seeds will help considerably to mitigate fungal infections. The antifungal protocol previously described will aid in the seeds having a better chance of getting past the most vulnerable stage of development for plants, which is soon after germination. Another way to suppress fungal infection is maintaining proper soil pH[14-16,19]. The acidic soils favored by ginseng suppress fungal growth, so maintaining proper soil pH and nutrition will help bolster ginseng crops versus infections.

Nematodes and Mammal Grazing

Nematodes are another risk for root crops. Areas infested with root knot nematode[15,16] should, therefore, be avoided. Other than nematodes, there are few animals noted for causing issues at the production level. The wild simulated model allows for biodiversity and natural predators can be used to keep pest populations in check.

Of mammalian threat, special note should be taken of rodents[15] and other forest dwellers. Some animals have been known to graze the plants or eat the berries. Some farmers have taken to trapping pests, fencing areas or employing biological controls such as cats to deter small rodent pests[15]. The practicality of such varies on a site by site basis however. Care should be taken however in the use of traps or fencing as to not endanger organisms other than the target pest.

Other Threats

Sometimes the greatest risk a farmer faces is that of theft[15,16]. This can be mitigated with care and planning. Not all ginseng thieves have the skills to detect more than the most obvious patches of plants, so forethought in planning beds can aid a farmer considerably. The best advice is to not advertise the locations of plantings[16]. Attempting to simulate natural conditions should make it more difficult to detect than with a monoculture patch. Making sure to plant in areas that are not directly visible to traffic, for example, not near well-traveled roads or paths will also make it more difficult to poach. As with any security measure, the goal is to make the effort of obtaining the product more difficult than it is worth. Spreading out beds, not informing individuals where they are and taking care to keep the location as natural as possible will not only aid in protecting a crop, but aid you in making a more wild resembling crop as well[16]. Care should also be taken when using more aggressive methods of persuasion. A farmer aggressively defending his property opens himself up to liability[15,16], and a level head should be maintained when implementing security procedures.

Post Treatment and its Effects

After harvest, roots are treated and dried before being sold. The Ministry of Agriculture, Food and Rural Affairs in Ontario, Canada commissioned studies to analyze several of the variables that can arise during ginseng harvest to see the effects they had on ginseng price. The study showed that the age of the plant affects the chemical compounds[23], with the ginsenosides increasing[23] in concentration over the four year period the plants were studied.

There was no significant difference in the plant dry matter content with harvest dates between August and November[23]. Starch concentrations were shown to decrease if harvesting was delayed; with scientists hypothesizing the plants were converting starch compounds into other polysaccharides for use by the plant[23]. This conversion of starch to other polysaccharides is a trend in many plants grown for their roots.

Ginsenosides were shown to be in lower concentrations in roots harvested later in the harvest period than those harvested earlier[23]. In the study, ginseng harvested in mid-September to November[23] was shown to have lower ginsenoside content than samples harvested earlier in the fall. As ginsenosides are chemical compounds of interest for their effects on human health, farmers wishing to maximize their concentration are better off harvesting earlier in the harvest season rather than later.

After harvest, roots are processed first by allowing a period of cold storage to affect the roots' condition and then a drying process, in which, the roots are dehydrated in a dryer. Temperatures for both these processes greatly affected the roots[23] and, therefore, their quality. Also, stable temperatures were shown to greatly affect the tissues, as tissues exposed to varying temperatures were impacted significantly in final appearance and chemical composition when compared to roots that were kept at steady temperatures[23]. Low temperature conditioning before kiln drying results in a darkening of surface color and wrinkling of the surface tissue, traits that have oftentimes been shown by the market to be favored in the past. The study indicated that temperatures for cold conditioning should be kept between 3° and 8° Celsius (37° and 46° Fahrenheit[23]). This temperature range allowed for the biological and chemical processes to occur that result in the desired results. Maintaining the temperatures between 37° and 46° Fahrenheit was shown to not significantly decrease the ginsenoside content of the harvested roots[23].

Another reason to maintain a steady temperature during the low temperature conditioning is that research has shown that extreme changes in temperature will kill the root at this stage, halting metabolic processes[23]. This will stop certain reactions from occurring, and can affect the value of the crop.

In the kiln-drying phase of post-harvest conditioning, studies have been performed to see optimum temperatures that dry out the root without negatively affecting the overall ginsenoside content of the tissues. The temperature ranges for optimal drying with the least impact on final ginsenoside content was 38° to 44° Celsius (89° to 111° Fahrenheit)[23,24]. Temperatures beyond 111° Fahrenheit were shown to negatively impact the final levels of all but one of the ginsenoside compounds[23,24], and therefore are not advised.

Best Practices

For the farmer, these practices can impact the value of the final crop. Does this mean that the farmer must have a chemical analysis lab to test each harvest? Obviously not. What these studies do give the farmer is information to help base their decisions on when to harvest during the fall, and how to treat the roots afterwards to achieve best quality. Since the treatments listed above have visual impact on the final product, following best practices will result in a better looking root for the market. Also, farmers can keep an eye on the condition of their roots to determine the processing stage of the product.

So a farmer should harvest early in the season, as allowed by the regulated harvest schedule of your state. For Tennesseans, the legal harvest time for ginseng is between September 1st and December 31st as of 2016. Farmers should cold treat their harvest before kiln drying, making sure to keep the temperatures as steady as possible for both the cold treatment and the kiln drying. For the cold treatment the roots should be kept between 37° and 46° Fahrenheit for the duration. For the kiln drying process, the roots should be kept between 89° to 111° Fahrenheit for the duration. Temperatures outside of these ranges were shown to harm the compounds the roots have produced during the growing season, leading to a drop in value.

For the cold treatment (temperatures between 37° and 46° Fahrenheit) farmers should expose the roots to a steady temperature for 30 days, as more time exposed than that had no benefit for quality. Periods shorter than 30 days can be used, however, experiments indicated that the roots continued to process and cure throughout the 30 day treatment[23].

For the kiln drying phase, research into the length of exposure to heat and the level of heat has been investigated. The length of kiln drying can be impacted by the temperature, the root size, the batch size and the equipment used[24]. Larger batches with thicker roots can take more time than thinner roots and smaller batches; however industry typically does not sort the roots by size[24], as that can be cumbersome to do in practice. Therefore the following drying times were determined by having a mix of size and quality roots to give more uniform guidelines:

> Roots dried at a uniform temperature of 89° Fahrenheit took an average of 190 hours to reach optimum dried condition, with optimal color, texture and dryness all achieved[24].

> Roots dried at a uniform temperature of 111° Fahrenheit took an average of 115 hours to reach optimum dried condition, with optimal color, texture and dryness all achieved[24].

While higher temperatures (111° Fahrenheit) can reduce drying times, researchers noted[24] that at those temperatures red streaks would form more readily in the root tissue, than at the lower temperatures (89° Fahrenheit) . This "red root" or red streak, are not valued as highly on the market, so farmers are advised to take care to maintain a steady temperature and to not over heat treat their harvested roots.

Do note, the times listed are averages. Farmers are advised to pay attention to root size and overall mass of the batch being heat treated as well. Occasionally checking the condition and look of the roots will help insure proper dryness levels are reached, as long as heat levels remain stable throughout.

Conclusion

American ginseng is an agricultural product with a long history of both cultivation and wild harvesting. The demand for the root is increasing and the market is always looking for a higher quality taproot in larger amounts than are currently available. This demand is driving both research into the efficacy of the plant's use and into better production methods.

An agricultural producer of American ginseng can use this information to aid in the implementation of a wild simulant production model of ginseng farming. Criteria, such as the botanical traits of the crop, the effects of the site characteristics and proper agricultural techniques can all contribute to the quality of the final product delivered to market. Preventative measures to limit loss due to disease or predation also can help mitigate costs, while proper handling and processing can help increase the value of the plants.

While all of these techniques are investments, the history of the ginseng's use, in both the Far East and in research, is an opportunity for agriculturalists in the Southeastern United States, especially those within the Appalachian regions. With a proper production model in place, farmers in the Appalachian region can use land typically less suitable for traditional crops, and increase their share of the ginseng market. By advising farmers on using land that would be considered marginal for other cash crops, valuable agricultural output can be increased. Through responsible cultivation methods farmers can, therefore, seek to supply the market's ever-growing appetite for quality root, while still preserving wild populations of ginseng for future generations.

Further Readings

The following are further readings and resources suggested by the authors for farmers wishing to go more in depth on a particular subject mentioned in the previous work. They have been prepared for the public by state Agricultural Extension programs, the University of Tennessee, other universities, The US Department of Natural Resources or by the US Department of Agriculture.

Phytophthora
https://extension.tennessee.edu/publications/Documents/W289-D.pdf
https://ag.tennessee.edu/EPP/Extension%20Publications/Phytophthora%20Blight%20Control.pdf

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http://extension.psu.edu/pests/plant-diseases/all-fact-sheets/rhizoctonia
http://www.ipm.ucdavis.edu/PMG/r785100811.html

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Appendix

Appendix I – Soil Nutrients

Soil nutrients can be divided into two categories. There are non-mineral nutrients and mineral nutrients. The mineral nutrients are further subdivided into macronutrients and micronutrients. Non mineral nutrients are hydrogen, carbon and oxygen and are obtained from the atmosphere and from water. Mineral nutrients are obtained from the soil, and are taken in by the roots. Each nutrient is vital in the life functions of a plant, and the division between micro and macro does not, in any way, signify level of importance.

Macro Nutrients

The macronutrients for plants are as follows; N P K Ca Mg and S.

Micro Nutrients

The micronutrients for plants are as follows; B Cu Cl Fe Mo Zn.

Appendix II – Calculating Elemental Compound Ratios from Fertilizer Formulations

Fertilizers are mixtures of elemental nutrients in a form that allows for easy incorporation into a growth media, be it soil or some other form. The elements in fertilizers are in compounds that are stable and safe to use. This means that one lb or kg of P_2O_5 does not equal one lb or kg of P. In this example, there are five units of O and two units of P for every one unit of P_2O_5 fertilizer. To determine how much of an elemental nutrient is in a unit of fertilizer one can use chemistry and simple math.

Formula Weights

To determine the amount of an element in a molecule one can use the formula weights of what makes up the compound to obtain a ratio. The ratio then can be used to find out how much of an element is contained in one pound or kilogram of a compound. With that, one can then determine how much of an element is applied per pound of the compound added. The following are atomic weights of elements commonly used in fertilizers are N(14); C(12); O(16); P(31); and K(39).

Continuing the example, to find the formula weight of P_2O_5 take and add the atomic weights of its components together (31 X 2) + (16 X 5) = 142. Then to find the proportion of P in P_2O_5 take 31 X 2 (the amount of P) / 142 (the formula weight of P_2O_5). This equals 0.4366, or 0.44. The formulas are as follows:

[(Molecular Weight of P) X 2] + [(Molecular Weight of O) X 5] = [Molecular Weight of P_2O_5.]

[(Molecular Weight of P) X 2] / [Molecular Weight of P_2O_5]. = [Proportion of P per unit P_2O_5]

From this one can determine the amount of phosphorous per pound of phosphate in the fertilizer. For every pound of P_2O_5 applied, 0.44 pounds of P is applied to the soil:

[Pounds of P_2O_5 applied] X [Proportion of P per unit P_2O_5] = [Pounds of P applied]

With the proportion of P per unit of P_2O_5 and the percentage of nutrients listed in the fertilizer guarantee on the bag, it is possible to calculate how much fertilizer is needed to result in a set amount of P added to the soil. The following formula can be used to calculate this:

[Pounds of Fertilizer applied] X [Fertilizer guarantee] X [Proportion of P per unit P_2O_5] = [Pounds of P applied]

If given the amount of P needed to be applied to the soil, and it is desired to know how much fertilizer to apply to achieve that amount, one can use the previous equation just by solving for the unknown. In this case, the unknown is the amount of fertilizer applied. So the resulting equation is as follows;

[Pounds of Fertilizer applied] = [Pounds of P applied] / ([Fertilizer guarantee] X [Proportion of P per unit P_2O_5])

To continue the example, if one knows that 100 pounds of P is required per acre to be added, and that the fertilizer has a guarantee of 46% and is P_2O_5, how much fertilizer per acre is required?

[Pounds of Fertilizer applied] = 100 / (0.46 X .44)

[Pounds of Fertilizer applied] = 494 pounds per acre needed to apply 100 pounds of P per acre.

These formulas can be used to determine both the P and the K amounts. For K, one must simply use the appropriate formula weight for the type of K one has as a source. If, for instance, potassium carbonate potash (K_2C0_3) is used as a source for K, the following equations can be used;

$$\text{Formula Weight of } K_2C0_3 = (39 \text{ X } 2) + (12) + (16 \text{ X } 3) = 138$$

$$\text{Ratio of K per unit } K_2C0_3 = (39 \text{ X } 2) / 138 = 0.57$$

$$\text{Pounds of Fertilizer applied} = [\text{Pounds of K applied}] / ([\text{Fertilizer guarantee}] \text{ X } [\text{Proportion of K per unit } K_2C0_3])$$

Appendix III – USDA Information on Scouting Plants

The following are links to the USDA plants database for information on plants useful in scouting locations. These plants all typically live in sites that favor ginseng growth, for example, sites that have the proper shade, soil type and drainage for American ginseng. The USDA has a wealth of information on their website pertaining to each of these plants.

Bloodroot - http://plants.usda.gov/core/profile?symbol=SACA13

Solomon's Seal - http://plants.usda.gov/core/profile?symbol=POBI2

Jewel Weed - http://plants.usda.gov/core/profile?symbol=IMCA

Galax - http://plants.usda.gov/core/profile?symbol=GAUR2

Trillium - http://plants.usda.gov/core/profile?symbol=TRPU3

Wild Yam - http://plants.usda.gov/core/profile?symbol=DIVI4

Hepatica - http://plants.usda.gov/core/profile?symbol=HENO2

Black Cohosh - http://plants.usda.gov/core/profile?symbol=ACRAR#

Wild Ginger - http://plants.usda.gov/core/profile?symbol=ASCA

Mayapple - http://plants.usda.gov/core/profile?symbol=POPE

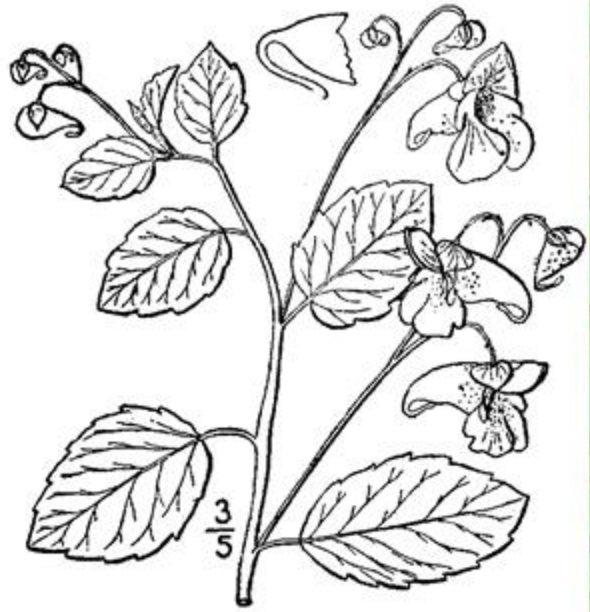
Spikenard - http://plants.usda.gov/core/profile?symbol=ARRA

Appendix IV – Scouting Plant Candidate Images

Bloodroot

Solomon's Seal

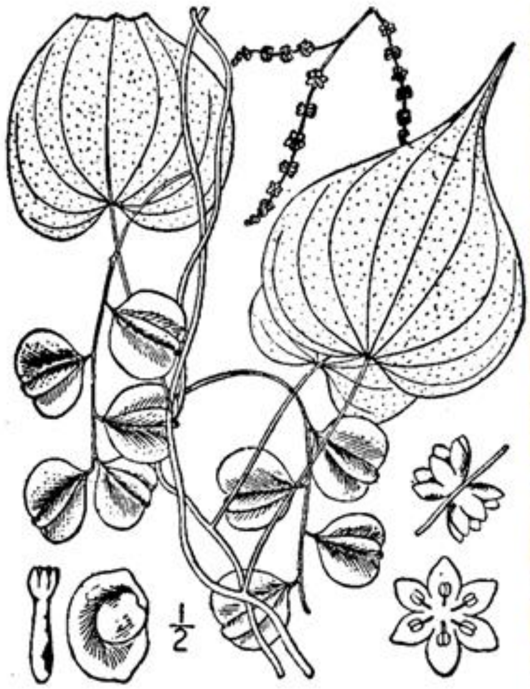
Galax



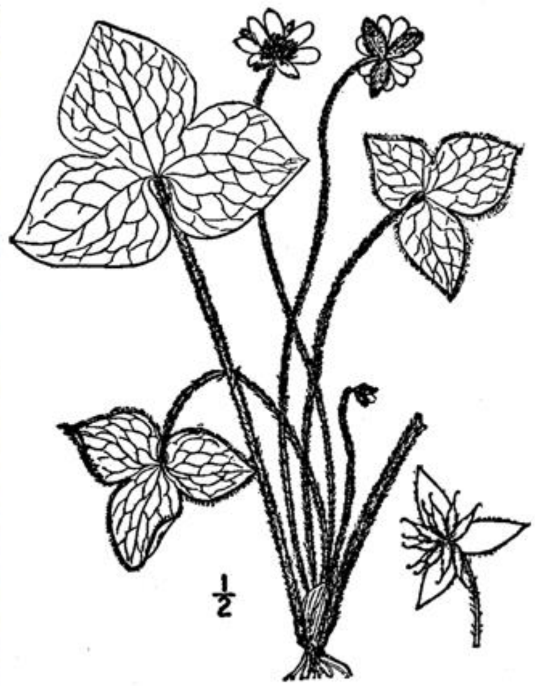
Jewelweed

Trillium

Mayapple



Wild Yam



Hepatica

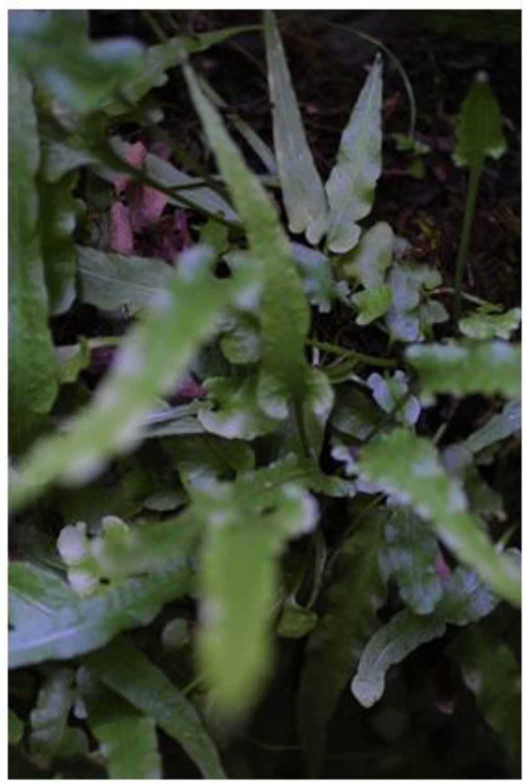
Black Cohosh

Wild Ginger

Spikenard

Some Example Ferns

Ebony Spleenwort



Walking Fern

Appendix V – Ginseng Pictures

Ginseng with Fruit

Ginseng at Five Leaf Stage of Development

Ginseng with Flower

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