Chestnut Growers of America

Promoting Chestnuts and
Connecting Chestnut Growers

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THE CHESTNUT GROWER

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Are Your Chestnuts Peelable?

By Richard Winkel, Winkel Chestnut Farm & Nursery, Allendale, Michigan

In This Issue

I want to tell you about a tool that might be useful to you. Last year (2019), I conducted an on-farm experiment to quantify chestnut peelability. The test was successful, and the testing method is one that others could reliably duplicate to provide a measure of an important chestnut characteristic. First, here is how my interest came about.

Over the course of 30 years, my chestnut planting had evolved to a collection of seedling Chinese trees, cultivars of Chinese cultivars as well as European and hybrid European trees, Japanese chestnuts, and a small sampling of American chestnuts. Trees have been selected and propagated to provide the longest possible harvest season for our U-pick chestnut customers. During the U-pick season of the year, I am no longer the farmer freely roaming my field. I become a shopkeeper tethered to my office. The one thing that puzzles me every year is that I see customers bringing nuts back from the field that impress me tremendously, and I have no idea what tree they come from!

Over the growing season of 2019, a plan evolved to get to better know my diverse set of trees. A list of characteristics was formulated to provide data for each

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About Chestnut Growers of America, Inc.

The purpose of Chestnut Growers of America is to promote chestnuts, to disseminate information to growers of chestnuts, to improve communications between growers within the industry, to support research and breeding work, and generally to further the interests and knowledge of chestnut growers. CGA advocates the delivery of only high-quality chestnuts to the marketplace.

CGA began as the Western Chestnut Growers in 1996 in Oregon where about 30 or so chestnut growers understood the need to join forces to promote chestnuts in the U.S. Eventually they realized that they needed to be a national organization and solicited memberships from every grower in the country, which took the membership to over 100. The name of the organization was changed to Chestnut Growers of America, Inc., and it was granted 501(c)(5) status. Annual meetings take place around the country in an effort to make it possible for a maximum number of people to attend. A newsletter, *The Chestnut Grower*, is published quarterly and distributed by mail and/or email. CGA maintains an extensive resource site available only to members containing information helpful in growing and marketing. Visit chestnutgrowers.org for more information.

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Issue	*Deadline*	*Mailed*
Winter	Dec. 20	January
Spring	Mar. 20	April
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Fall	Sept. 20	October

Editorial Opinion

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Message from CGA President Roger Blackwell, Chestnut Grower

I hope your chestnut harvest season is going well. Unfortunately, this year should go down in chestnut history as weird. Many of our growers have experienced unusual weather in frost conditions in May after the trees are budding and not enough rain in the summer and the expansive fires in the West. Whatever chestnuts we have are selling fast and maybe someday we will have enough to satisfy the demand for good quality Chestnuts in the USA.

This next year for our 2021 annual CGA meeting, we hope to have our Annual meeting in Pennsylvania. The dates of the meeting are yet to be determined. We will have more information in the January Issue for everyone's planning schedules.

In this newsletter we have several great articles submitted by our members. Dick Winkel conducted an on-farm experiment on chestnut peelability and shares a method that may interest other members. Art and Carl DeKleine have been considering the problem of alternate year bearing (AYB) in chestnuts and suggest a protocol for mitigating AYB in chestnut orchards.

Finally, CGA would like to thank all who helped organize the virtual networking event, *Connections Across the Chestnut Supply Chain*, which took place in September. Kate McFarland, one of the members of the organizing committee, provides a helpful summary of the event.

CGA wants to thank the individuals who submitted articles for this newsletter, and I encourage others in our organization to provide articles for future newsletters. We are all learning each year something new about growing chestnut trees in orchards.

I hope you all have enough chestnuts in the fall 2020 to continue for the future and a wonderful holiday season.

Best regards,

Roger

Building Connections Across the Chestnut Supply Chain

By Kate MacFarland, Agroforester, USDA National Agroforestry Center

Across the northeast, farmers are increasingly looking to chestnuts as a new option for their farms. While there is significant need to provide more information about chestnut establishment and production approaches for the region, there is also interest in understanding how chestnut growers can access markets.

Over the last few years, partners from the Pennsylvania Chapter of the American Chestnut Foundation, the Pennsylvania Bureau of Forestry, and USDA National Agroforestry Center, along with chestnut farmers in the region have been learning from existing chestnut cooperatives and aggregators across the country.

Through visits to Route 9 Cooperative in Ohio, Chestnut Growers Inc. in Michigan, and the University of Missouri's Horticulture and Agroforestry Research Center in Missouri, these partners have learned more about what it would take to support aggregation and cooperative efforts for chestnuts in the northeast. This work was supported by a Pennsylvania

Specialty Crop Block Grant and Northeast SARE Farmer/Rancher grant.

One of the consistent recommendations was the need to work together. Because the Chestnut Growers of America meeting, planned for June 2020 in State College PA, was cancelled due to COVID-19, the group organized two online networking events in September 2020. The group had heard from many people who are working to create relationships and infrastructure to aggregate, process, and distribute chestnuts, but much of this work is happening in parallel.

The goal of the virtual events was to build networks among chestnut growers and those involved in aggregation, marketing, and distribution. The events were a success with over fifty participants from the northeast and beyond. As part of registration for the events, the organizers asked registrants to fill out a questionnaire to learn more about who planned to participate. This helped to tailor the events and served to get insight into how people, especially those in the northeast and mid-Atlantic, are working with chestnuts.

Most participants were farmers (61%), but others were technical assistance providers, nursery operators, aggregators, distributors, financers, or researchers, and some had multiple roles. Of the 57 registrants who filled out the survey, 39% were from the northeast, 25% from the mid-Atlantic, 30% from the Midwest, 4% from the south, and 2% from the west. Of those who indicated how many acres of chestnuts they had planted, 23% had 10-50 acres of chestnuts, 20% had 5-10 acres of

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Consumer Survey Reveals that FDA Unlikely to Consider Chestnuts 'Not Consumed Raw'

By Roger Blackwell, CGA President

A group of chestnut leaders have tried to establish that chestnuts are not consumed raw by most consumers through a consumer survey via Michigan State University. This activity was due to the Food Safety Modernization Act being open until November 9, 2020 to convince the FDA that chestnuts are not consumed raw by the consumer and therefore should be exempt from the FSMA law.

I want to provide an update on the consumer survey results which has been received from Dr. Trey Malone at MSU. It quickly became clear with some simple data evaluation that we would not be able to meet the FDA standards, which state that the commodity is consumed uncooked by less than 0.1 percent of the U.S. population and the commodity is not cooked by the consumer on less than 0.1 percent of eating occasions. Here is a little description of the results.

The survey received 1,005 representative respondents. Respondents were asked, 'Have you ever eaten a chestnut?' 494 (49%) responded yes, and 511 (51%) responded no. Of those 494 respondents who indicated they had eaten a chestnut, 231 were able to correctly identify an edible chestnut out of three photo choices that included an edible chestnut, a water chestnut, and a walnut. Of the vetted respondents who could identify chestnuts AND had eaten a chestnut (n=231), 33% (n=76) indicated they had consumed raw chestnuts on at least one eating occasion.

I know this is not the results the industry had hoped for, but unfortunately these are the results we got. The consensus is that we have a lot of work to do when it comes to consumer education around chestnuts. Erin Lizotte, MSU Extension Agent will be reaching out to our ag literacy team to see what they recommend. Additionally, CGI and most of our members in CGA are interested in better understanding our options, particularly the 'not to be consumed raw' labeling option. We will need to explore this option to be developed to be approved by the FDA. We will need help from chestnut growers across the country.

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tree. At harvest season, I hired a college student to be my farm U-pick (We-pick?) customer. Her mission was to select nuts from each tree as they matured and fell. Analysis would be performed post-season to tally the results leading up to a full orchard comparison. It quickly became clear that most of the things I wanted to see were easily and readily observable. However, several characteristics would take more analysis to allow a useful comparison between the trees.

Chestnut peelability was one of the characteristics that fell into the class of "not readily observable". A rating more specific than "easy to peel" or "hard to peel" was hoped for. A survey of available literature revealed that I was not the first person to follow this path. UPOV[1] notes "Seed coat: adherence to kernel (fresh fruit)" as one of the distinguishing characteristics between chestnut cultivars. The associated rating is vague at best.

Research leading to cultivar selections[2] had developed the hot oil peeling (HOP) test to quantify the peelability of chestnuts. In following research[3] the final output scale of the measurement was revised. As a bonus, the methodology was documented so clearly that I felt I could duplicate it for my post-season on-farm test.

Method Step by Step

Here is a summary of the HOP method as described by Takada[3]:

1. Nuts were harvested after the bur opened and were stored at 5°C for one month, and
2. 10 randomly selected nuts per tree were used for the evaluation of peelability, or PP.
3. After the shells were removed,
4. the nuts were fried in canola oil at 190°C for 2 min, following the HOP method[2].
5. PP was scored by visual evaluation on the basis of the percentage of the surface area that peeled away without scraping, on a scale graded in 10% increments, where

- 0 represents 0%,
- 5 represents <10%,
- 15 represents 10%–20%,
- 25 represents 20%–30%,
- 35 represents 30%–40%,
- 45 represents 40%–50%,
- 55 represents 50%–60%,
- 65 represents 60%–70%,
- 75 represents 70%–80%,
- 85 represents 80%–90%, and
- 95 represents 90%–100%.

Figure 1. The outer shell was peeled by hand with care not to cut the inner pellicle.

Our Method in Practice

Our experience with the HOP method was as follows:

1. Our tested chestnuts were harvested as they fell over a three-week period. Samples of five or more nuts were collected in paper lunch bags, labeled by tree/cultivar and harvest date. The nuts were stored in our cooler at 40°F (4.4°C) and 80% relative humidity until peelability testing.
2. For our peelability test, we used five nuts of each cultivar. Immediately before the HOP peelability test, the nutshell (pericarp) was removed by hand (Figure 1) by hand, taking care not to slice or otherwise damage the inner skin (pellicle) attached to the chestnut.
3. Canola Oil was readily available at the local grocery store and was used in our test. We used an electric fry pan set to 374°F (190°C) (Figure 2). Proper temperature was verified using a hand-held IR thermometer. The two-minute frying time was rigidly adhered to. At completion of frying the nuts were removed from the oil using a large slotted spoon, placed on an absorbent paper towel, arranged with identifying information, and photographed (Figures 3-4) for documentation.
4. Upon removal from the oil, pellicle had either freely separated from the nut, or the pellicle was completely attached to a nut and was left as is, or the pellicle partially free of the nut and could be removed using tweezers.
5. A numeric score was assigned to peelability by realizing that using five nuts for a HOP test, each nut

Figure 2. Nuts cooked in hot oil for two minutes.

represented 20% of the test sample. If three nuts peeled totally clean and two nuts did not peel at all, the score given was (3x20% + 2x0% = 60%), giving a PP score of 65. If four nuts peeled totally clean and one peeled halfway, the score given was (4x20% + 1x10% = 90%), giving a PP score of 95.

Comments on Our Processing

The original description of the HOP method stresses testing the nuts four weeks after harvest. In our test, the nuts peeled were harvested over several weeks, stored in uniform conditions, then HOP-processed in a single session. That is, we did not adhere to the four-week harvest-to-test period.

Use of five nuts for our initial HOP survey struck us as a good on-farm compromise between effort required and accuracy of results. Time required to hand-peel the nuts prior to hot oil treatment is the most labor-intensive part of the HOP process.

Simplifying the HOP output to eleven degrees of peelability (0, 5, 15…95) seemed at first to be an odd final step to a numerical ranking. Why not assign a peelability percentage? The final ranking makes sense considering the small sample size of the tested nuts. Too much emphasis could be put on comparing a 90% ranking for one chestnut vs a 92% ranking for another nut, so better to place them in the highly peelable category.

Figure 3. Pellicle of an easy peeling chestnut peeled completely free of the kernel.

Figure 4. Pellicle of this chestnut peeled partially free of the kernel.

Where do we go from here?

Would we use the HOP method for assessing peelability again? Yes. We can do this, and the results both confirmed some suspicions and revealed subtle distinctions between cultivars.

Is peelability an absolute measure of goodness? No. This is one trait among many which might be significant for a given use of the nuts. However, when the planned use of a chestnut is well understood, then peelability might be a crucial piece of information.

What would we do differently? We would harvest nuts on one day if possible so that a uniform storage period (four weeks) would allow HOP testing to be done on one day. That is, the effect of variation of storage time would be removed from the testing.

How would we use the HOP method in the future? First, this could be part of a rapid and logical assessment of cultivars we propose to add to our planting. A few hours of assessment could help avoid years of tending the wrong cultivar. Secondly, testing might help to further understanding the behavior of a given cultivar. Does peelability improve with extended storage after harvest? Do cultural practices in the planting influence peelability? And on a grand scale, does regional climate influence peelability of a given cultivar?

And finally, should you try this HOP peelability experiment? Yes! You will better understand the characteristics of the nuts you grow and sell. And you will become confident in the use of one more readily available tool in your chestnut grower's toolkit.

References

[1]UPOV, 1989. Guidelines for the conduct of tests for distinctness, homogeneity, and stability. Chestnut (Castanea sativa Mill.). TG/124/3 (ed). International Union for the Protection of New Varieties of Plants, Geneve.

[2]Shoda, M., N. Takada, T. Saito, Y. Sawamura, and K. Kotobuki. 2006. A method for quickly removing pellicles from chestnuts by deep frying cooking oil. Bull. Natl. Inst. Fruit Tree Sci. 5:21–27 [in Japanese with English summary].

[3]Norio Takada, Masahiko Yamada, Sogo Nishio, Yutaka Sawamura, Akihiko Sato, Noriyuki Onoue, and Toshihiro Saito. Existence of Genetic Differences in Pellicle Peelability in Japanese Chestnut (Castanea crenata Sieb. et Zucc.). Cultivars and Selections with Difficult-peeling Pellicles. Institute of Fruit Tree and Tea Science*, NARO, Tsukuba 305-8605, Japan.*

Alternate Year Bearing: A Case Study for Chestnuts

By Art & Carl DeKleine, DeKleine Orchards, Hudsonville, Michigan

Introduction

Alternate Year Bearing (AYB) refers to the tendency of fruit and nut trees to produce a greater than average crop one year, and a lower than average crop the following year.

It has been noted with increasing concern that chestnuts exhibit AYB. It will be exceeding difficult for Chestnut Growers to have a profitable business if AYB cannot be mitigated.

So little has been written about chestnut AYB that this case study will hypothesize an AYB scenario for a hypothetical chestnut variety.

To help us understand AYB in chestnuts, we will consider AYB in other nut and fruit tree crops, especially pecans and apples.

Quantifying AYB

An **AYB Index** has been useful in other crops to help identify AYB characteristics. Understanding the index is helpful but also challenging.

The AYB Index, ***I***, measures the crop-load change from year to year.

Let's concentrate on the first transition

$a_1 \Rightarrow a_2$. Let's call $C = a_2 + a_1$ the **crop load**, and

$\Delta C = |a_2 - a_1|$

(the absolute value of the difference) the **change in crop load**.

For this single transition, ***I*** $I = \frac{\Delta C}{C} = \frac{|a_2 - a_1|}{a_2 + a_1}$

1 ≥ ***I*** ≥ 0, 1 ≡ **Bad** ----> 0 ≡ **Good**

Let $a_1, a_2, a_3, \ldots, a_n$ denote a sequence of crop yields over an n-year period. ***I***

$$= \frac{1}{n-1}\left\{\frac{|a_2 - a_1|}{a_2 + a_1} + \frac{|a_3 - a_2|}{a_3 + a_2} + \ldots + \frac{|a_n - a_{n-1}|}{a_n + a_{n-1}}\right\}$$

The n-year periods give rise to (n-1) transitions;

$a_1 \Rightarrow a_2$,

year 1 to year 2, for example. The index ***I*** simply averages the yearly changes.

It is common in many fields of study to consider a percentage change *p* in crop yield,

$a_2 = p \bullet a_1$

1 ≡ **Bad** ----> 0 ≡ **Good**

Knowing *p* and a_1, helps us calculate a_2. For example, if we want to determine next year's crop size and anticipate a 30% decrease, we can solve $a_2 = 0.70 * a_1$.

The AYB index has some nice properties: It is easy to use and understand. If the crop yield goes from a_1 to 0 (total loss), ***I*** = 1 (100% loss). If the crop load stays the same, $a_2 = a_1$ (no change of yield), ***I*** = 0. The values of ***I*** are always between 0 and 1.

Percent change *p* in crop yield from one year to the next is easy to understand.

What we would like to do now is use ***I*** to calculate the percent change *p* in crop yield, and vice versa. The (1,0) AYB index changes to a (0,1) percentage-chance relationship.

Creating an index ***I*** using percentage change *p* requires some analysis.

Let's assume that the yield goes from a higher value to a lower value, $a_2 = p \cdot a_1$, where $0 < p < 1$. (Note, if there is no change, p = 1, <u>not 0, **Good**</u>. And if there is a total loss, p = 0, <u>not 1, **Bad**</u>.

Then

$$I = \frac{\Delta C}{C} = \frac{|a_2 - a_1|}{a_2 + a_1} = \frac{|pa_1 - a_1|}{pa_1 + a_1} = \frac{1-p}{1+p}$$, and

$$p = \frac{1-I}{1+I}$$

Figure 1 illustrates how ***I*** and *p* are related. For example, if *p* = ½, ***I*** = 1/3.

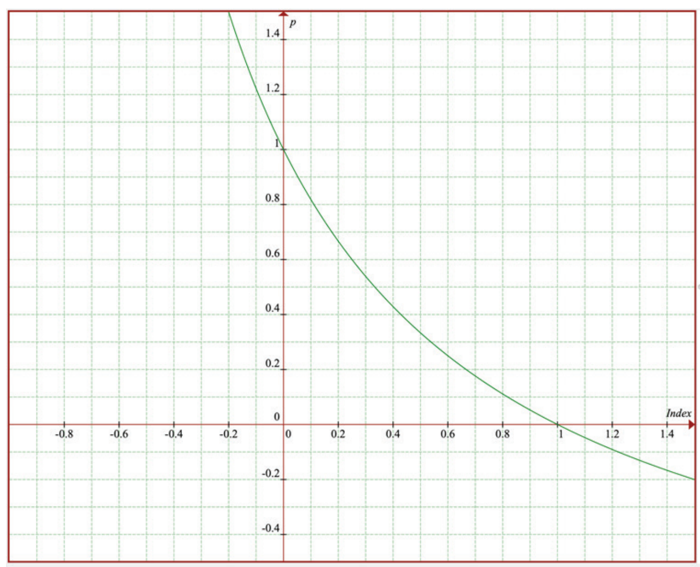


Figure 1. *The relationship between* **I** *and* p.

So how does this help us? The pecan growers have noted that if it is a good year and ***I*** values are above 0.65 (*p*<0.21), the coming year may not be so good.

The Rationale for Looking at Other Nut and Fruit-tree Crops

Although the common AYB disorder is exhibited by many nut trees (acorns, beech nuts, walnuts, pecans, filberts, cashews, pistachios, etc.), temperate fruit trees (apples, apricots, peaches/

almonds, pears, prunes, etc.), sub-tropical fruits trees (avocados, olives, etc.), tropical fruit trees (litchis, mangos, etc.), and citrus trees, we will primarily consider AYB research associated with nut trees closely related to chestnuts.

Plants and trees (much like animals) are remarkably similar in their functions and characteristics. The sun shines down on the earth at a constant rate and provides solar energy for the trees. The leaves use the solar energy to capture carbon and turn it into carbohydrates (sugar). Photosynthesis is remarkably similar across all plants. The tree distributes the carbohydrates to various parts of the plant to help it grow. Some of those carbohydrates are used to make nuts (the reproductive tissue).

Since plants of similar classification have similar genetics, plant chemistry, phenology, and characteristics (including AYB), studying plants with a similar classification will provide reasonable conjectures for chestnuts. Pecans seem to be the most highly studied AYB tree nut.

A word of caution – not all varieties are the same. Each variety has its own identifying characteristics. An AYB Index has been calculated for 12 pecan varieties, from 0.32 to 0.72 (from p = 0.515 – half of the crop is lost – to p = 0.168 – less than 1/5 of the crop is lost).

Understanding the mechanisms responsible for AYB

Alternate Year Bearing (AYB) refers to the tendency of fruit or nut trees to produce a greater than average crop one year, and a lower than average crop the following year.

And where does the tree get its carbohydrates (energy, sugars, starch, etc.)? From the sun by leaf photosynthesis.

And how does the tree regulate its carbohydrate use? Plant biology and hormones.

Simply put, a heavy bearing depletes a tree's energy reserves (carbohydrates) and jeopardizes its flower formation for the coming year, resulting in poor crop yields the following year.

Chestnuts (and other related tree nuts) produce nut buds for this year's crop last year. Nut buds for next year's nuts will be initiated on this year's shoot growth beyond the cluster of nuts being produced for the current year. Thus, to produce next year's nuts, a branch grows nuts on the tree for this year, grows substantial shoot growth beyond this year's crop to grow nuts for next year, and then initiates fruit buds for next year's crop. During July and August, the amount of energy needed to mature a heavy crop load and support this year's bark, leaves, and roots will most likely exceeds this year's energy production by the sun. To compensate, a tree draws energy for this year from surrounding tissues needed to support next year's crop.

Several observations support the theory that trees rob energy reserves from surrounding tissues: (1) During a heavy crop year one can observe the yellowing of leaves near maturing nuts, a result of drawing carbohydrates from the leaves. (2) In the spring of the year following a heavy crop load, shoot growth is stunted and many new shoots die. (3) There seems to be an inverse relationship between new leaf buds and flower buds – more leaf buds imply fewer flower buds and fewer leaf buds imply more flower buds; leaf buds and flower buds compete for carbohydrates in the spring; and flower buds require a bigger carbohydrate uptake in the spring than leaf buds.

The amount of solar energy arriving at the earth's surface on a clear day is on the order of 1 kW/m^2 per hour. The m^2 area needs to be facing the sun directly, not at some off angle. The tree knows this and thus makes many leaves around the tree looking at the sun from many angles.

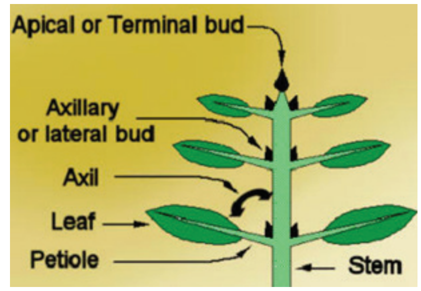
For various reasons, photosynthesis, the process by which green plants transform light energy into chemical energy, is not 100% efficient. Most estimates suggest that photosynthesis is about 5% efficient.

Most trees use about 10% of their annual carbohydrate production for reproduction (flowers, nuts and fruit). This puts a limit on the amount of nuts a tree can produce in one year. Our task is to figure how the tree responds when asked to produce an over-abundance of nuts.

Tree structure and biology

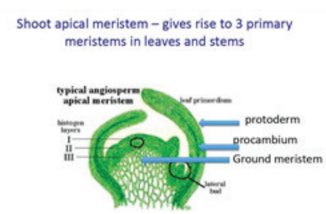
Understanding the structure and biology of chestnut trees is important for understanding the mechanisms responsible for AYB.

Understanding AYB necessitates looking at chestnut tree phenology: (1)dormancy (*quiescence* and *vernalization*), (2) bud development, (3) leaf development, (4)



shoot/branch development, (5) inflorescence emergence, (6) flowering, (7) nut development, (8) nut maturity, (9) senescence, and the beginning of dormancy all over again.

Meristematic tissue in plants consists of undifferentiated cells (meristematic cells) capable of cell division. Cells in the meristem can develop into all the other tissues and organs that occur in plants. There are three types of meristematic tissues: **apical** (at the tips), **intercalary** (in the middle), and **lateral** (at the sides). **Apical meristems** are the completely undifferentiated (indeterminate) meristems. These differentiate into three kinds of primary meristems. The primary meristems in turn produce the two secondary meristem types. These secondary meristems are also known as **lateral meristems** because they are involved in lateral growth. There are two types of apical meristem tissue: **shoot apical meristem** (**SAM**), which gives rise to organs like the leaves and flowers, and **root apical meristem** (**RAM**), which provides the meristematic cells for future root growth. Shoot apical meristems are the source of all above-ground organs, such as buds, stems, leaves and flowers.



Plant growth and development are influenced by many interacting factors: temperature, light, water, oxygen, CO_2, carbohydrates, nutrients, plant genes, hormones, and enzymes.

A **bud** is a swelling or protuberance in the meristematic tissue of a stem or branch. A **bud primordium** is the simplest set of cells capable of triggering bud growth. Buds typically have the potential to produce more buds: stem buds, leaf buds, and flower buds.

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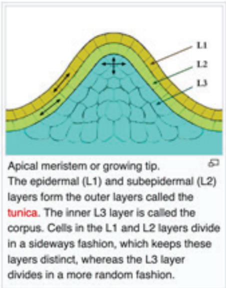
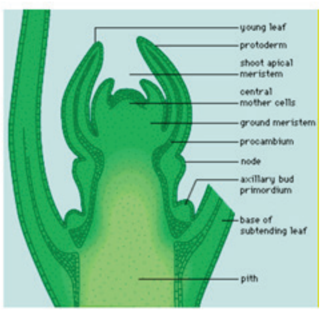


Lateral buds typically produce a leaf and three new buds. It is most common to see one leaf and a dormant bud in the leaf axil. A second dormant bud is inside the visible dormant bud. At the end of the summer the leaf will fall off and the axil bud will remain dormant during the winter. In the spring, the tree will tell each of the dormant buds what it will become – a stem, leaf, or flower. Note, it is not uncommon to see three chestnut branches emanating near each other.

Lateral buds producing a shoot can become an apical or terminal bud over time. Apical or terminal buds are more functionality than lateral buds.



Induction is the physiological process in which the plant tells the bud what it will become. Through induction, the bud becomes competent to continue its developing as intended. **Bud differentiation** indicates that the bud has advanced to an irreversible state. Induction can be reversed, but differentiation is irreversible.

OK, so what is next? Dormancy has ended. It's spring, and the weather is getting warmer. The buds start to swell.

We should sit back, think about last year, watch, and take pictures and notes.

At this point we recall that last year was an **off-year**. This should be a **good-year**.

We should recall that that AYB and nut harvest is a 2-year-long process, and mitigating AYB is a year-long effort. **Stated differently, every year we are growing two nut crops, this year's nut crop and next year's nut crop.**

The apical buds on branches start to leaf-out. The branches start to grow. Lateral leaves start to grow on the branches, and the branches gets longer.

What else do we recall? The branches grow quite vigorously over the course of the year. Most leaves remained green throughout the growing season. There were a few burs, but not many. Carbohydrates were used to build up the tree. There were not many nuts, but the few were relatively large.

Now that our tree starts to respond to a new spring, what can we expect?

We must continue to wait. At about 600 GDD catkins should appear in many leaf axils. At about 800 GDD some flowers should appear. At about 1,000 GDD pollen should be flying.

Then comes the question: How many flowers are on the tree this year?

Way more than the tree can support!!!

The pictured tree has a 4.7" diameter trunk, and a 7' canopy radius. The trunk area is 17.3 in^2. Two branches with a combined branch area of .75 in^2 had 36 flowers. We can thus estimate 830 flowers on the tree.

If all flowers get pollinated and produce nuts, we can assume that the weight of the nuts to be about 41,500 g. (50 g/bur), or 91 lb. A reasonable estimate for fresh chestnuts is 756 Cal./lb. Hence, 68,796 Cal. is the estimated Calories produced by the chestnuts on the tree.

The canopy radius is 7', and the canopy's shaded area is 154 ft^2, or 14.3 m^2.

Also, we will assume that (1) the solar energy reaching the tree = 1 kW/m^2 = 860.42 Calorie/($m^2 \cdot$ hr), (2) the tree will receive 860 hours of sunshine during the growing season, (3) solar energy per season = 739,961Calories/m^2, (4) photosynthesis is about 5% efficient, and (5) the tree's energy from the sun = 529,072 Calories.

Thus, to grow the 91 lb of nuts, our tree will need to use (68,796 Cal) / (529,072 Cal), or 13% of the sun's yearly supply of energy.

Most fruit and nut trees use about 10% of the sun's yearly supply of energy for reproductive purposes, including flowers and burs – especially during an on-year. If our tree follows the same pattern, it will use about ½ of its burs to produce the yearly supply of nuts. During an off-year the tree may spend only 2.5% of the year's supply of energy for nuts. Apples and pecans suggest that AYB can be mitigated by using 5-7% of the year's energy supply for nut production.

Too many flowers! Not all the flowers get pollinated. Some nuts cannot get enough carbohydrates to keep going and become duds. As the nuts grow, they compete for carbohydrates and either make it, or they don't, and the nuts that do grow do not get as big as they might otherwise.

Branches growing nuts this year will not have the carbohydrates needed to grow vigorously beyond the nuts; the branches will exhibit short seasonal growth.

Also, the **shoot apical meristematic (SAM) buds,** beyond the growing nuts, do not have enough carbohydrates to initiate flower development next spring either. Next year will be an **off-year**, if something is not done to mitigate the issue.

Cultural practices minimizing AYB in other fruit and nuts

As chestnut growers, we look around to see what other AYB fruit and nut growers are doing. Peach, apple, pecan, and pistachio growers have developed protocols over the years for AYB.

Generally, when excess fruit or nuts are removed from the tree early in the growth season, the mitigation response is for AYB is much better.

Peach. As a kid, we went through the orchard in the spring with a hose-on-a-stick to knocked off small peaches so that the remaining peaches were 4-5 inches apart.

Apple. Some growers use hand thinning, others use growth regulator sprays.

It is noted that the potential size of a given pome fruit is determined early in the season (with some relationship to the available carbohydrates) and growth proceeds at a uniform rate thereafter. This uniform growth rate permits an accurate prediction of the mean apple-harvest size as early as mid-summer. The growth rate, once established, is not easily altered; and fruit numbers will determine fruit size at harvest. Post bloom thinning generally occurs at the 3-15 mm fruit size.

Harvest fruit size is important for apples. Everybody likes a big apple. Big apples have storage problems. The problem is to keep apples smallish and minimize AYB.

The University of Wisconsin has developed a precision apple thinning program to calculate the ideal target crop load. Different crop loads for different varieties (mature and young) are given. From this, fruit density/cross-sectional limb or trunk diameter is calculated.

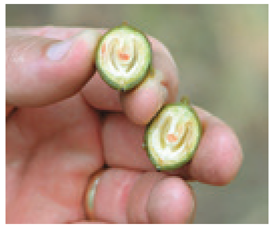
After estimating the number of flowers on a tree, and the desired crop load, one can estimate the percent of flowers or fruit to remove. It is not uncommon to estimate a 7-9% flower fruit set rate, and a 50% apple-cluster thinning.

Pecan. Most growers use a harvest shaker to shake off small nuts early in the season.

For maximum AYB mitigation, pecans should be thinned after post-pollination drop and when the nut ovule is 50% expanded. Typically, this is a 10-14-day interval.

Pecans grow on fruiting shoots, with one or more nuts per shoot. Trees with almost 100% of the shoots bearing fruit, and cluster sizes greater than three, are overloaded and should benefit from thinning.

When thinning, count the number of



shoots that have one or more nuts. The number of nuts to be removed depends on the cultivar (and the AYB Index), size, crop load anticipated, and environmental factors. More generally, if the cultivar nut size is small, greater than 70 nuts/lb, thin to 60-70% of the fruiting shoots. If the nuts are larger, 50-70 nuts/lb, thin to 50-60% of the fruiting shoots. If the nuts are large, < 50 nuts/lb, thin to 45-50% of the fruiting shoots.

Pistachio. As one pistachio information bulletin put it, "Attempts to alleviate the AYB cycle by nutritional and growth regulator sprays have not been successful. However, some success has been achieved with rejuvenation pruning."

Note, growth regulator sprays in chestnuts will take some time to establish: the most effective chemicals, the most effective rate, and the most effective timings.

Some fruit growers are using tractor-mounted or handheld string blossom thinners to remove flowers, and some are pruning apical buds before blossoms emerge. Both of these methods seem problematic without a lot of research and experience.

A proposed protocol to minimize chestnut AYB

Since the crop size in a given year is determined during the spring and summer of the previous year, the proposed protocol should be used in the early post-pollination period each year, 7-9 weeks after pollination when one can observe a small embryo inside a growing ovule.

Step 1. Measure the trunk diameter dT, in inches, about waist high. Measure the canopy radius rC in feet.

Note, the trunk diameter will help estimate the number of potential nuts on the tree. The canopy diameter will help estimate the yearly calories provided by the sun.

If $rC \approx 1.5 * dT$, one number can be estimated measurement from the other.

Step 2. Estimate the number N of burs on the tree. Refer to ***Opportunities for Early and Accurate Crop Estimates***, MSU Extension, Pete Conrad and Erin Lizotte.

Step 3. Using a 25-bur count, estimate the proportion p of burs having a visible growing ovule.

Assume that each visible growing ovule, given the opportunity, will give rise to a viable nut bur. Assume also that each viable nut bur will provide 0.11 lb/bur (50 g/bur) of nut meat, and that a reasonable estimate for fresh chestnuts is 756 Cal./lb.

Step 4. Calculate the hypothetical number of calories C^* for the tree in question.

$C^* = N * p * 0.11 * 756$

Step 5. Calculate the canopy's shaded area in ft^2.

$A = \pi * (rC)^2$

Assume that (1) the solar energy reaching the tree = 1 kW/m^2 = 860.42 Calorie/($m^2 \cdot hr$), (2) the tree will receive 860 hours of sunshine during the growing season, (3) solar energy per season = 739,961Calories/m^2 = 68,744 Calories/ft^2, (4) photosynthesis is about 5% efficient, (5) the tree's energy from the sun = 68,744 * 0.05 * A Calories, and (6) chestnut AYB can be mitigated by using 6% of the year's energy supply.

Step 6. Calculate the suggested carbohydrate level to be used by the tree for nut production that will mitigate AYB.

Cal = 206.232 * A

If C^* > Cal, it would be wise to remove burs from the tree. C^* = Cal would be ideal.

Step 7. If C^* > Cal, remove the proportion Cal/C^* of nuts from the tree, retaining [1 - Cal/C^*] nuts on the tree.

Example:

Step 1. dT = 4.7", rC = 7', (rC = 1.49 dT, close enough)

Step 2. N = 830

Step 3. p = 0.88, (22 out of 25 visible growing ovule)

Step 4. $C^* = N * p * 0.11 * 756$ = 60,740 Calories

Step 5. A = * $(rC)^2$ = 154 ft^2

Step 6. Cal = 206.232 * A = 31,724 Calories

Step 7. C^* > Cal, therefore remove 52% of the burs and retain 48%

The big question is, can chestnut growers develop an easy economical method to remove burs from chestnut trees early in the season?

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chestnuts, 17% had 1-5 acres of chestnuts, and 40% had 0-1 acres of chestnuts. Most chestnuts were young or just planted, with 33% of respondents with trees that were just planted, 42% with trees that are 1-5 years old, 9% with trees that are 5-10 years old, 12% with trees that are 10-20 years old, and 3% (1 grower) with trees that are 20-50 years old.

Many participants saw additional roles for themselves in the future, with the most common future roles being aggregator, processor, nursery operator, and distributor. The two largest barriers to their work that respondents selected were time and financial constraints. These were followed closely by access to information, equipment needs, finding other local growers, and land access. Over one third of respondents have received grants and/or loans for their chestnut work, with the most common funding sources being USDA NRCS Environmental Quality Incentives Program, USDA NIFA's Sustainable Agriculture Research and Education program, USDA AMS Specialty Crop Block Grants, and other USDA NRCS programs.

Nearly all the respondents suggested that chestnuts' biggest opportunity is that it is a perennial crop. Many respondents also were interested in the opportunity chestnuts provide for farm diversification and joining with others in local food movements. Other opportunities identified by many growers were access to larger markets and availability of known productive cultivars.

At the first event on September 1, speakers with significant experience in chestnut markets shared their lessons learned and advice. Erik Hagan of the Savanna Institute interviewed Roger Blackwell (Chestnut Growers, Inc.), Greg Miller (Empire Chestnuts & Route 9 Cooperative), Kathy Dice and Tom Wahl (Red Fern Farm), and Bill Davidson (Savanna Institute).

Blackwell shared some of the details of Chestnut Growers Inc.'s history and operations, including its support from Michigan State University and how it has used the blueberry industry as a model. Miller shared Route 9 Cooperative's history, relationships with growers, and some details about how the coop functions as an economy of scale and its interest in expansion. Tom Wahl and Kathy Dice spoke about their work with Prairie Grove Chestnuts, as well as their experience with U-pick on their own farm. Davidson wrapped up by sharing what he has learned through analyzing the chestnut industry over the past few years, including ways that farmers are incorporating chestnuts into agroforestry systems and the potential for value-added products by working with existing mill infrastructure. These speakers all indicated that chestnuts require patience and a willingness to work with unknowns, and also emphasized that collaboration with others is key to success.

The first event also included a chestnut roundtable, which allowed any participant who was interested a chance to give quick introductions to their work. These speakers included:

- Michael Judd and Jane Dennison, SilvoCulture
- Chris Smyth, Southern Ohio Chestnut Company
- Zach Elfers, Keystone Tree Crops Cooperative
- Johann Rinkens, Fields Without Fences/Restoration Agriculture Development
- Sandy Anagnostakis, Connecticut Agricultural Experiment Station
- Gary Wyatt, University of Minnesota Extension
- Rick Hartlieb, Castanea Farms LLC
- Carol Williams, New Rhineland, LLC
- Luke Tarvin
- Harry Greene, Propagate Ventures

The first event concluded with an extensive question and answer session, in which speakers and participants discussed topics including information resources, best practices, yield estimates, and value-added production.

The goal of the second event held on September 10 was to facilitate deeper discussions among those interested moving forward towards next steps to establish chestnut cooperatives and other aggregation organizations. Participants were placed into virtual breakout rooms and moderators facilitated discussion in each room. The first session matched farmers and distributors to better understand what farmers need from distributors and what distributors need from farmers. The second session grouped participants within sectors, bringing farmers, technical assistance providers, and aggregators together to talk with each other and discuss their specific challenges and opportunities for collaboration. The last session grouped participants by geography to determine specific next steps within a state or region. Discussions in the breakout sessions were energetic and new relationships were established.

At the end of the sessions, moderators shared key points from the sessions. Participants said that while the events were a good start, there is interest in other ways to find nearby chestnut growers. Many participants are involved with chestnut suitability mapping projects and indicated interest in creating a mapping group to share methods and results. Several conversations focused on technical assistance opportunities, including field days, opportunities for engaging with NRCS, and demonstration sites. Several topics came up that the group felt warranted further discussion at a future time, including scaling orchards for success and profit, insurance needs, and enterprise budgeting. A common theme across many sessions was the challenge of growing the community of chestnut growers, the processing infrastructure, and the market for chestnuts all at the same time.

Together, farmers already growing chestnuts, those interested in growing chestnuts, distributors, aggregators, and cooperatives, along with the array of agencies and organizations that provide technical and financial assistance, are working to support the growth and management of this important tree crop in the northeast and other regions. With such interest, this discussion will be sure to continue in the months leading to the 2021 Chestnut Growers of America meeting and at the meeting itself.

To learn more about these events as well as view recordings of the sessions visit: ecosystems.psu.edu/research/chestnut/meetings/connections

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THE CHESTNUT GROWER

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