

Topics in Vegetable Crop Management: Volume III- Fact Sheets

A class project prepared by the students of Vegetable Crop Management
(HORT 480A2)

Taught by
Dr. Mark Uchanski (Instructor)
Tyler Mason (Graduate Teaching Assistant)

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A class project prepared by the students of Vegetable Crop Management (HORT 480A2) under the direction of Dr. Mark E. Uchanski (Associate Professor of Horticulture) and Tyler J. Mason (Graduate Teaching Assistant) at CSU, Department of Horticulture and Landscape Architecture.

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Introduction:

I have been teaching or helping to teach horticulture classes at the University of Illinois at Urbana-Champaign (UIUC), New Mexico State University (NMSU), and CSU since 2002. In that time, I have assigned numerous writing assignments on various horticultural topics. However, it has always bothered me that it was really only the instructor (and perhaps a few teaching assistants) that ever read these writing assignments. As a result, this information is not accessible to other students or the general public. To remedy this situation, I borrowed a novel concept from one my mentors (Dr. Bob Skirvin- UIUC) and decided publish the students' writing assignments in a form that could be accessed by other students and/or the general public.

At the start of this semester, the students in this class must select a topic for their writing assignment, and you will see a wide diversity of subjects represented. The students did a great job compiling information about each of their individual topics for their vegetable crop of choice in a form that was approachable by other students as well as the public. The end result of this effort is this bound volume on that same topic. This is the second (Volume II) of, hopefully, many volumes relating to vegetable crop management at CSU. Copies of this bound volume have been supplied to the students that contributed to it; there is also a copy in the instructor's private collection (211 Shepardson).

It was a joy to teach this class and learn from the students' fact sheets. I am looking forward to future volumes.

A handwritten signature in black ink, reading "Mark E. Uchanski". The signature is written in a cursive style with a long horizontal flourish at the end.

Mark E. Uchanski
Associate Professor of Horticulture

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Jerusalem Artichoke

By Axel Anderson

Irrespective of its name, the Jerusalem artichoke (*Helianthus tuberosus*) was originally consumed by Indian Tribes in North America. It is a hardy plant that can be cultivated in a variety of different environments, although it performs best in a cool climate (Gazeley, 2012). A vegetable is classified as a plant or part of a plant that is cultivated for the purposes of human consumption. The plant is cultivated mainly for the edible underground tuber, which is the why the Jerusalem artichoke is considered a vegetable (Rhodes, 2008). A recent gardening revival produced several new cultivars like ‘Copperclad,’ ‘Mulles Rose,’ and ‘Waldoboro Gold’ (Weaver, 2013).



Fig 1. Jerusalem artichoke tubers (Weave 1

Helianthus tuberosus is not affected by many pests or diseases and will usually outgrow any weeds that begin to surface, in fact it is sometimes considered a weed because it is so hardy. They are low-maintenance crops and many gardeners discover that these plants are hard to remove once they are established (Weaver, 2013). They grow in many different soils, but flourish in a soil pH around 6.5, and better soil generally leads to higher yields. Studies have shown improvements in yields through fertilization with nitrogen at a rate of 60 to 120 pounds per acre, and potassium at a rate of 150 pounds per acre (when coupled with the nitrogen application) (Cosgrove, et al., 1991). However, it is important to note that every soil should be tested prior to any fertilization to limit both cost to the

producer and pollution in the environment. Soils heavy in clay make harvesting the Jerusalem artichoke challenging so typically a sandy loam works best (Swiader and Ware, 2002).

Due to the extensive height of the plant especially late in the season, the Jerusalem artichoke is susceptible to wind damage if not properly supported during growth. They can be topped (accomplished by cutting the apical meristem to encourage less upward growth and more shrub-like growth) if high winds are anticipated and the shift of plant growth regulators will shift to tuber development and less on ascending vegetative growth. The plant produces small yellow flowers, grows up to twelve feet tall and yields carbohydrate-heavy tubers. This characteristic is similar to the potato plant (*S. tuberosum*) except instead of producing starch, the Jerusalem



Figure 2: Jerusalem artichoke blooms

artichoke stores carbohydrates in the form of inulin which is converted to sugar during vernalization. A vernalization period represents overwintering, a requirement for some propagules to be sprouted or to begin the second phase as a biennial seed-producer, and can be

accomplished in a cool dark place such as a root cellar (Cosgrove, Oelke and Doll, 1991).

Tubers are harvested after the first frost or they can be left underground to overwinter. Mulching is appropriate to prevent freezing. Countries lacking long-term produce storage infrastructure would benefit from the harvesting post-winter approach (Gazeley, 2012). If they are left underground overwinter they can be harvested only when necessary which reduces the need for storage and potential for spoilage (Swiader and Ware, 2002). Because many gardeners claim it is difficult to remove once it is established and it can provide a source of carbohydrates

in the colder months without a need for storage, Jerusalem artichokes may be a reliable source of food for many countries. Qualities like flavor, size, or texture would be valuable traits to breed for in the tuber but for home gardeners the plant also has an aesthetic quality. Some breeders may consider trying to increase plant height or change the colors of the flowers and leaves. Tuber yields vary from 5 to 25 tons per acre, and costs from seed to harvest are \$1300-\$1600 which does not include storage or transportation (Cosgrove, Oelke and Doll, 1991).

The Jerusalem artichoke has many different preparation methods such as raw, cooked, and boiled. Like many vegetables, natural toxins like oxalate and trypsin may develop in the fruit but they are removed through boiling. Because of the thin outer skin, 80-85% of the tuber can be utilized for consumption (Judprasong, Archeepsudcharit and Chantapiriyapoon, 2016). Interestingly, excess consumption of the Jerusalem artichoke leads to flatulence. So, one may opt for another tuberous vegetable for date night.



Figure 3: Jerusalem artichoke chips (Bur 1

The general history of vegetables as roots, rhizomes, and other underground carbohydrate and nutrient-rich foods is extensive. People consumed tubers and storage rhizomes throughout history and they were often staples for hunters and gatherers before agriculture's inception. Tuberous plants like the Jerusalem artichoke continue to be a sustainable crop because "a few "seed" rhizomes or tubers can be used to produce many plants, each of which can provide an abundant supply of food plus propagules" (Simpson and Ogorzaly, pg. 201). In addition, these

plants may have been used for their medicinal qualities for treating cuts, inflammation and pain (Yang, He and Corscadden, 2015).

So why is Jerusalem artichoke production on a larger scale not as common as it is in other tuberous vegetables? Perhaps it is because “their carbohydrate is inulin, not starch, and humans cannot readily digest inulin. Consequently, the starch calories ... do not translate into human metabolized calories” (Simpson and Ogorzaly, pg. 187). Even though these vegetables grow in abundance and require little maintenance, their value as a potential food crop and energy source has not been revealed until recently, so commercial production is currently limited. Recent interest in developing these tubers for feedstocks is increasing because of their efficient inulin production; inulin can be processed similar to refining sugar from sugarcane. Inulin, fructose and biofuel production from the Jerusalem artichoke is being extensively researched, but it is also a source of other bioactive compounds that have antifungal, antioxidant or anticancer properties (Yang, He and Corscadden, 2015).

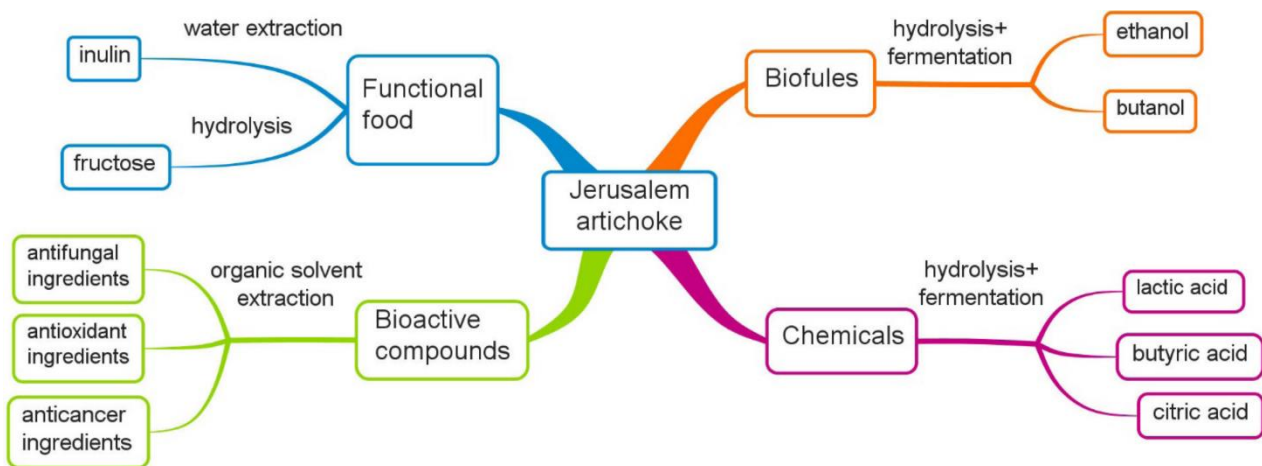


Figure 4: Components of a Jerusalem artichoke (Yang, et al., 2014)

I chose this crop because I am interested in unique vegetables that are not under mass production. These may be a potential solution to the growing issue of world hunger because they are low-maintenance, hardy and can reduce or eliminate storage requirements due to their overwintering capability. They can be refined into biofuel or grown for aesthetic value in the garden. I think the future of nutrition lies in not only improving the crops we currently cultivate, but diversifying them as well. Trying vegetables with unique properties like the Jerusalem artichoke in commercial production could boost economies and nutrition levels in areas where soil quality is poor or food is in short supply. I have a love of horticulture.

I wrote this to commemorate that feeling:

*Every garden is a Victory Garden to me;
Feeling the breeze linger on droplets of hard-earned sweat and the whisper of the robins
In the trees is an instrument that never goes out of tune,
A personal orchestral obsession frolics on dicotyledonous plateaus.
Plants are an origin, an amendment and a solution;
The meaning of life is photosynthetic.*

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Pumpkins throughout History

By Clark Arborgast

The Cucurbit family consist of 95 genera and 965 species of herbaceous vines. Commonly known vegetables that fall into the Cucurbitaceae include watermelon, squash, cantaloupes and cucumbers. The Cucurbitaceae is also referred to as Cucurbits or the gourd family. *Cucurbita*, one of the genus's, consists of five species that humans have cultivated for their edible fruits. The *Cucurbita pepo* yields varieties of plants that are commonly referred to as pumpkins or winter squashes. This report will be focusing on the geography, history, cultivation and culture of pumpkins.

The origin of *Cucurbita pepo* dates back 8,000-10,000 years ago to the southern region of Mexico. From southern Mexico the *Cucurbita pepo* spread to Texas, up the Mississippi River and into Illinois. *Cucurbita pepo* eventually was introduced to Asia in the fifteenth century when explorers began bringing native plants to their home countries. The word pumpkin comes from the Greek work “pepon” which translates to “large melon”. Later “pepon” was adjusted by the British to “pumpion” and finally amended to pumpkin by American colonists. Additionally, the word pumpkin has no scientific correspondence to its taxonomy.

Cucurbita pepo was first cultivated for its edible flowers. Traditional cultivars of *Cucurbita pepo* yielded multiple pumpkins per plant that could weigh up to twenty pounds. *Cucurbita pepo* physical characteristics vary greatly by cultivar. Pumpkins range from under one pound to over 1,000 pounds and have varying colors at maturity such as green, white, and orange. Pumpkins provide an excellent source of provitamin beta-carotene and vitamin A, and contains moderate levels of vitamin C (Nordqvist, 2017). Beta-carotene, the yellow and orange pigments found in

fruits, vegetables, and eggs, has been recognized as an anti-oxidant which may slow down cognitive decline.

Almost all parts of a pumpkin are edible, including stems, seeds, and leaves. When ripe, a pumpkin is usually prepared and eaten steamed, roasted, or boiled, while raw pumpkins are commonly used to create livestock feed. Most pumpkins that are orange and round are used for ornamental purposes only, while pumpkins used for consumption are typically tan colored and elongated. Fifteen percent of all pumpkin production acreage is dedicated to pumpkins intended for consumption.

Pumpkins are still widely cultivated for ornamental and consumption use worldwide. According to the USDA, in 2015, the per capita consumption of pumpkins reached a record high of 5.4 pounds (Wells, 2015). Currently, the US produces more than a billion pounds of pumpkins annually on 50,000 acres of farm land (Penn State Extension, 2005). In 2016 the pumpkin industry was valued at over \$207 million (AGMRC, 2018). Pumpkin production is centralized mostly in the midwest and eastern states. Illinois produces more pumpkins within its borders than the next five top pumpkin producing states combined. Illinois alone accounts for half the pumpkin production in the United States (AGMRC, 2018).

The market for pumpkins in the United States could be described as seasonal and limited, most of the production is centered with a harvest in late September. Within the last decade there has been a resurgence in pumpkin flavored products such as the Starbuck's Pumpkin Spiced Late and the pumpkin flavored craft beer market. Between 2011 and 2015 total sales of pumpkin-flavored food, beverages and goods in supermarkets and stores across the U.S. increased almost 80 percent. In 2015 the total sales of these products were estimated to be \$360 million (AGMRC, 2018).

Most people in the United States associate pumpkins with the fall season and especially the holiday of Halloween. A tradition that many Americans are familiar with is the cutting and decorating of pumpkins which are named Jack-O-Lanterns. This tradition comes from an Irish folktale about a man nicknamed Stingy Jack. The legend goes that Stingy Jack had cheated on a bet with the devil, and when he died, God found him too unsavory for heaven and the devil would not let him into hell. Banished from heaven and hell Stingy Jack was left to roam the earth with only a lantern to guide his way, this was the story of Jack-Of-The-Lantern. The Irish began to make their own Jack-Of-The-Lantern, carving faces into potatoes and onions and placing candles inside. When immigrants from Ireland came over to the United States they brought their tradition with them and soon found that pumpkins made the perfect Jack-Of-The-Lantern.

Pumpkins have become an iconic part of the season of fall. Today, families around the United States continue the Irish tradition of carving Jack-O-Lanterns. Entire farms and events are centered around the harvesting of pumpkins such as pick-your-own pumpkin patches. Limited time pumpkin flavored food and beverages have become much anticipated seasonal events. Pumpkin pie, pumpkin cookies and muffins, and pumpkin beer have become seasonal favorites. Many speculate that the recent increase in the demand for pumpkin flavored products can be attributed to the Starbucks Pumpkin Spiced Latte. Since Starbucks began offering its limited availability beverage in 2003 there has been a resurgence of pumpkin flavored products in the market (Tyko, 2018). Companies such as 7-Eleven, Cheesecake Factory, Cracker Barrel, Dairy Queen, Duncan Doughnuts, IHOP, Krispy Kreme, Starbucks, Steak & Shake, Culvers and Kellogg have all followed suit, each offering a seasonally available pumpkin flavored product.

Pumpkins are a significant vegetable within the American culture. North America has been breeding and producing *Cucurbita pepo* for thousands of years and production is predicted to continue far into the future. Over the last few decades the seasonally available vegetable has become even more popular due to new pumpkin flavored foods and beverages. With the fall season quickly coming upon Colorado State University's campus there are many ways that you could interact with pumpkins. One could join the Colorado State University's Horticulture Club for an exciting day in the field harvesting their pumpkins. Carving pumpkins with family and friends is a great way to have fun and remember Stingy Jacks legacy, and don't forget to save the seeds to make a delicious snack! When temperatures drop, enjoy a warm pumpkin coffee by the fireside, or relax in the company of good friends with the flavorful taste of a pumpkin beer. Look around this Fall season, there are new pumpkin flavored products coming out every year, what will be the new pumpkin craze this year?



Figure 1. Popular Pumpkin Flavored Products

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Globe Artichoke

By Emma Balunek

The artichoke, more formally known as the globe artichoke (*Cynara scolymus*), is related to thistle, as the leaves of the artichoke have thorns on them (Figure 1; Gaffney). The family they



Figure 1: Globe Artichoke (Gaffney)

are included in is Asteraceae which is the family of flowering plants (2001). Other vegetable crops in the same family are lettuce and endive (The Editors, 2016). The technical term for the globe, the part that is eaten, is called a bract. Artichokes are consumed at the immature thistle stage. If it was let to grow to

maturity, it would be a big purple thistle flower (Figure 2; 2015). Because the artichoke is eaten before it is pollinated, it is considered a vegetable. But, even though it flowers, only the fleshy part is eaten, not the flowers, which would make it a fruit (The Phytophactor, 2008). This artichoke fact sheet will discuss artichoke history, growing artichokes and the best location to do so, artichoke consumption, and fun facts.



Figure 2: Mature Artichoke (2015)

History:

Artichokes are believed to have descended from the cardoon which is a tougher, pricklier thistle related to plants native in north Africa and Sicily (Figure 3; Rupp, 2014). Artichokes, which originated in the Mediterranean, are now grown in southern Europe, north Africa, South America, and in California in the United States (2001). There were two types of edible thistles known to the first-century romans, "...one which 'throws out numerous stalks immediately it

leaves the ground,' which sounds like a cardoon; the other 'thicker, and having but a single stem' and purple flowers, which may be a progenitor of the modern globe artichoke." (Albert)

Artichokes are believed to have many beneficial medicinal effects including curing baldness, strengthening the stomach, freshening the breath, and promoting the conception of boys (Rupp, 2014)



Figure 3: Cardoon (Albert)

Location:

In the U.S., 75% of the artichokes are grown in Monterey County, California, but the state grows nearly all the nation's artichokes (California Artichoke, 2017). This coastal county has ideal conditions for growing artichokes with its cool, foggy summers and frost-free winters (Bertelsen et al., 1995). The crop value of artichokes was ranked 17th in 2014 for this area of California, contributing over \$150 million to the state's economy. In this same season, almost 3 million, 22-pound crates of artichokes were grown on 6,199 acres in California. Artichoke production provides hundreds of jobs as they are a labor-intensive vegetable, making labor a large cost of production.

Growing Artichokes:

The perennial artichoke plant grows 3-6 feet tall and up to 6 feet wide with offshoots that are sent up from the crown where the flower grows (Figure 4; Texas A&M AgriLife Research, 2017). New growth starts in the fall and the immature flowers start forming in the spring (Bertelsen et al., 1995). The most



Figure 4: Artichoke Plant
(Texas A&M AgriLife Research, 2017)

common cultivar, 'Green Globe', produces robust plants with large hearts (Drost, 2010 and California Artichoke, 2017). Other cultivars include 'Imperial Star', 'Big Heart', and 'Desert



Figure 5: Cultivars (Kura)

Globe' (Figure 5; Kura). The most important factor for growing artichokes is having a well-drained soil though they do prefer organic, rich, fertile soils. To prepare the soil, add organic matter and a complete fertilizer to a depth of six inches. Artichokes need about one to two inches

of rain per week as they do best in cooler, moist soils. It is suggested by Utah State University Extension to side dress artichokes with two teaspoons per plant of nitrogen fertilizer every four weeks after transplanting (Drost, 2010).

Most artichokes are “propagated vegetatively to maintain the genetic consistency needed to assure uniformity among artichoke buds (4),” mainly due to commercial acceptability (Bertelsen et al., 1995). There are some seed-propagated cultivars out there now and these varieties are cheaper than vegetatively-propagated varieties. Productivity declines as the plants age. Farmers typically keep artichoke plants around for 5 to 10 years. To mitigate potential insects and disease problems, it is a good idea to rotate artichokes with other crops. However, most growers do not practice rotation because of the minimal availability of good artichoke land (Bertelsen et al., 1995).

A field of artichokes can be picked more than once a week because the artichokes mature at different times (California Artichoke, 2017). Artichokes are ready to be harvested when the flower bud reaches its maximum size but before the bracts begin to separate. After the first bud is picked, the secondary and tertiary buds begin to grow. These can also be harvested. As quickly

as possible the artichokes need to be cooled to 40 degrees F in the packing shed. Artichokes are individually inspected to cull insect or mechanically damaged or cosmetic impurities in the crop. They are mechanically sorted based on size. They can be stored for 3-4 weeks if they are kept in the ideal conditions, 33 degrees F and 95 to 100% relative humidity (Bertelsen et al., 1995).

Consumption:

Artichokes are grown for the fresh market. The ones that do not make it there are processed mainly for the heart (Bertelsen et al., 1995). Most artichokes will probably end up in dip because that is one of the most common preparation methods. When cooked, the leaves have a soft,

fleshy paste that can be scraped off (Figure 6;

Bauer, 2015). Artichokes are low in calories,

25 calories each, and are good sources of

potassium, vitamin C, folate, magnesium, and

fiber. An interesting fact is they are the

vegetable with the highest number of antioxidants, according to the USDA (Steele, 2015). But,

artichokes are not a very popular vegetable in the American diet, with less than one pound per

person consumed annually. Artichokes are seasonally available, mostly in the spring (Bertelsen

et al., 1995). Spain consumes 33% of global consumption. Per capita, they consume nearly 18

pounds (Avramenko, 2018)!

Fun Facts:

One fun fact is Castroville, California is considered the “Artichoke

Center of the World” as it was where the first commercial artichoke

fields were planted by Italian immigrants (California Artichoke,

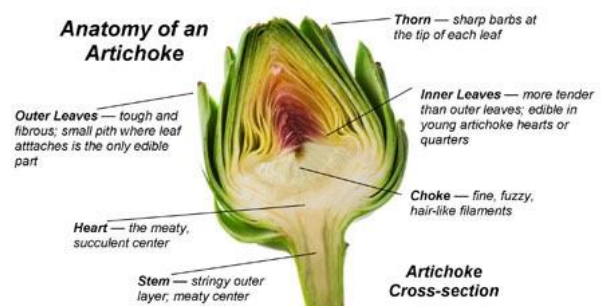


Figure 6: Artichoke Anatomy (Bauer, 2015)

fields were planted by Italian immigrants (California Artichoke,

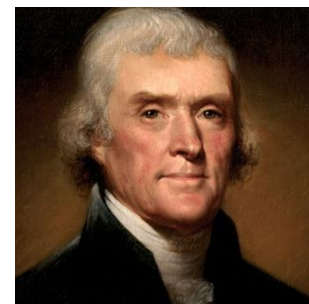


Figure 7: Thomas Jefferson (A&E Networks Television, 2018)

2017). Another interesting fact is President Thomas Jefferson grew artichokes around 1767 at his home in Monticello, Virginia (Figure 7; A&E Networks Television, 2018).

Conclusion:

Artichokes are an interesting crop. They are part of the Asteraceae family and related to the cardoon (Rupp, 2014 and 2001). The artichoke is consumed at the immature thistle stage and can be considered both a fruit and a vegetable (The Phytophactor, 2008). 75% of artichoke production in the U.S. is located in one county in California (California Artichoke, 2017).

Artichokes are a labor-intensive crop that will end up being consumed in the fresh market mainly for artichoke dip.

I chose to focus on artichokes because they are one of my favorite vegetables, and I do love artichoke dip. Also, I do not know much about them and they are an underrated vegetable. I learned that they have many health benefits including having the highest number of antioxidants of any vegetable (Steele, 2015)! Not many people eat artichokes unless they are made into a creamy dip. It seems like people are afraid to cook fresh artichokes, perhaps because it takes a long time to cook them. In addition, eating an artichoke is an event in itself. Pulling each leaf and scraping the fleshy part off with our teeth is messy and takes a long time. Removing the inedible choke before eating the delicious heart takes some skill. Preparing and eating artichokes is savored in a special meal in our family. I am excited in springtime/early summer because it is artichoke season. I usually steam them and then make a vegan mayo-based dip with red wine vinegar, country Dijon mustard, and some seasonings. It is delicious! My mom introduced me to artichokes and even my picky sister enjoys them. Over the years, we have invited friends to join us for an artichoke dinner, and will continue to spread the word about how delicious, nutritious and fun artichokes are to eat!

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Irrigation Methods for Vegetable Crops

By Hayes Bartlett

Irrigation is one of the most important aspects of any vegetable production system, and many irrigation methods have pros and cons. It is important for a farmer to select which method works best for their situation to maintain efficiency. Irrigated vegetable production in the United States accounts for 1.9 million hectares. That accounts for nearly 7.5% of all irrigated land in the US, and methods are carefully planned by farmers to remain practical and improve efficiency (Locascio, 2005). One of the most important considerations when choosing an irrigation system is the water-use efficiency of that method. Many factors can play a role in reducing water use efficiency and some methods of irrigation are better suited for specific environments or situations. I will be discussing the three most common irrigation methods in this report, including surface, drip, and sprinkler irrigation.



Figure 2: Onion crops grown under drip irrigation. (Hayes Bartlett, 2018)

Surface Irrigation:

One of the most common methods of irrigation among vegetable crops is the use of surface irrigation, consisting of more than 80% of the worlds irrigated land (Maisiri, Senzanje, Rockstrom, Twomlow, 2005). This method is based on using the power of gravity to pull the water into the plants' root zone and is often distributed by a system of furrows that run alongside the rows of vegetables. These furrows can be filled using siphons that draw water



Figure 3: Furrow irrigation in California. (Steve Goossen/AgStock, 2014)

from nearby water sources, making it a simple and low-maintenance method of irrigation (Kumar, Asrey, Mandal, and Singh, 2009).

One benefit of this method is that it is often simple and cost effective to set up as furrows which can be dug alongside the rows and then filled with water. This makes it a popular method for large-scale farms as tractors can be used to quickly create furrows with little effort and cost (Locascio, 2005). Some of the major downsides to furrow irrigation is the requirement for large volumes of irrigation water and the efficiency of water delivery to the soil. Despite the widespread use of surface irrigation methods, water use efficiency is often 40-50% meaning that half or more of the irrigation water applied is lost (Maisiri, et al., 2005). Irrigation water-use efficiency of furrow irrigation is less efficient than that of drip or micro sprinkler irrigation and requires more water to achieve the same yields (Kumar, et al., 2009). This inefficiency is

largely caused by evaporation, with as much as 36% of the applied water being lost to evaporation (Maisiri, et al., 2005). Inefficiency of furrow irrigation can be further exacerbated by soils with poor drainage. This causes the irrigation water to remain on the surface for longer time periods leading to more evaporation (Maisiri, et al., 2005).

Drip Irrigation:

Drip irrigation is an irrigation method that relies on a slow and precise application of water. Drip irrigation is a very efficient method of irrigation and can reduce water usage by 35% compared to surface irrigation methods (Maisiri, et al., 2005). This increased efficiency can reduce irrigation costs for farmers while still providing the same yield as surface irrigation methods. Another benefit to drip irrigation is that it allows farmers to implement fertigation, the application of fertilizers through irrigation water (Kumar, et al., 2009). While irrigation efficiency does not have a significant impact on crop yield, fertilizer application methods can.

Fertigation can allow for greater yields by enhancing the nutrient availability through soluble fertilizers compared to fertilizers that have been incorporated into the soil (Kumar, et al., 2009). One downside to drip irrigation is that it requires a higher initial investment and a more expensive installation than a furrow irrigation system (Kumar, et al., 2009). Another downside to drip irrigation



Figure 4: Drip irrigation of strawberries in coco fiber blocks. (Hayes Bartlett, 2018)

is that it is often difficult to apply this method to large vegetable fields as it would require high water pressure, a labor-intensive installation, and a high upfront cost (Maisiri, et al., 2005).

Overhead Irrigation:

Overhead irrigation is an irrigation method using devices that emit the water above the crop in a method similar to rain. This method can range from the use of small sprinklers that spray a section of a field, to large central pivots that rotate around large plots of vegetables. Overhead irrigation is more efficient than furrow irrigation, with losses typically around 20% of applied irrigation water (Dukes, Zotarelli, and Morgan, 2010). While drip is more efficient than overhead irrigation in terms of water use, certain situations such as short spacing between rows or a large field might make it more practical to implement an overhead irrigation system.



Figure 5: Sprinkler irrigated field where rows were too close to implement a drip system practically. (Hayes Bartlett, 2018)

Another benefit of overhead irrigation systems is that farmers have the ability to easily apply treatments such as fungicides to large portions of their crops (Viera and Sumner, 1999). In the event of a pathogen or pest problem, this can give farmers the ability to treat their crops on a large scale without needing expensive machinery or tools. One challenge that overhead irrigation systems pose is maintaining uniformity of irrigation within the field (Dukes, Zotarelli, and Morgan, 2010). This can lead to certain areas getting less water than others, and can lead to differences in crop health and yield in specific areas. Another issue with sprinkler systems is

that they can experience water use efficiency losses during high wind or high heat, making them more effective to use at night (Dukes, Zotarelli, and Morgan, 2010).

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Garden Beet

By Elana Bernholtz

Introduction

Beta vulgaris, more commonly referred to as a beet, belongs to the family Amaranthaceae and is a biennial root that is indigenous to the Asia Minor and European areas. Other names commonly used include beetroot, garden, table, and/or red beets. According to the formal definition, a vegetable is the edible portion of a soft-stemmed plant which might include the leaves, stalk or root- in the case of beets, this includes the root and the leaves, Figure 1 (Corleone, 2018). This vegetable was first utilized for consumption around the third century AD but was grown for thousands of years prior to this for medicinal purposes; beetroot was previously regarded as a laxative, a cure for bad breath, coughs and headaches, and even as an aphrodisiac (Department of Agriculture, 2009). Humans originally ate the large beet leaves and stalks, consumed like chard (a close relative) but the root part of the beet was later cultivated for consumption in either Germany or Italy around the mid-1500s. That being said, Northeastern Europe was the first area to embrace the beet root as a dietary staple; it was valued as one of the only vegetables that grew well throughout winter (Avey, 2014). Despite only growing well during fall and winter, beets were so well liked in Ancient Rome and Greece that methods were developed in order to produce them during summer months as well. The beetroot is now a popular garden vegetable widely grown in Germany and France, with lesser amounts throughout Europe, Africa, Asia, and South America. Usually used in salads (Figure 2), the top of a beet acts as a good

source of Vitamin A, and the roots are a good source of Vitamin C (Anderson, 2000 & Department of Agriculture, 2009).

FUN FACT #1: Beets are most commonly a dark red color due to betalains. However they also come in other hues ranging from white to yellow to a candy cane looking red-and-white cultivar known as Chioggia (Avey, 2014).

FUN FACT #2: The betalain-rich juice of red beets was used as a cheek and lip stain by women during the 19th century, which led to the saying, “red as a beet” (Avey, 2014).

FUN FACT #3: Beets contain unique antioxidants called betalains, which are currently being studied as a potential weapon to fight cancer (Avey, 2014).



Figure 1: Picture of beetroot with tops (Corleone, 2018).



Figure 2: Example of beets in a salad (Avey, 2014).

Production/ Management

In its earlier form the beet closely resembled parsnip rather than the bulb shape we are accustomed to seeing. They are closely related to swiss chard, sugar beets and mangels; stock beets are available but considered to be too coarse for human consumption and thus grown for stock feed (Anderson, 2000). Table beets are grown all

over the world in temperate areas because they obtain their best color and quality when grown in a cool climate (Department of Agriculture, 2009). Excessively hot weather causes the appearance of alternating light and dark red concentric circles in the root (“zoning”), while too cold of weather results in slow or no growth. The plants can stand some mild freezing, but the roots must be removed from the ground in the fall before a hard freeze (Sanders, 2001) because prolonged periods of low temperatures during winter can induce bolting (Department of Agriculture, 2009).

Beet seeds should be sown when the soil reaches an optimal germination temperature range of 50-85°F and covered with 0.5 to 0.75 inches (Sanders, 2001). The seeds should be spaced 2 to 4 inches apart within a row, and rows should be 12 to 24 inches apart (Sanders, 2001). For good stand establishment it is best to keep the soil moist by irrigating with 0.5 to 0.75 inches of water every 4 days until emergence; after the seedlings have emerged 1 inch of water per week is sufficient (Department of Agriculture, 2009). Once established the beets will need to be thinned out, which is usually done when seedlings are 5-7 cm apart. High density plantings of up to 25 lbs of seed per acre will help obtain maximum yields, but 10 lbs of seed per acre is adequate for average yield (Sanders, 2001). Soil tests may also contribute to increasing productivity; soil tests determine the nutrient content of the soil and identify the microorganisms present which in turn can help identify additional regulation practices, like fertilization or fumigations, that may be necessary. Additional management practices like crop rotation, seed treatment, sanitation, and the prevention of over-watering should also be taken in order to control pests and disease (Sanders, 2001 & Department of Agriculture, 2009).

Beets grow best in deep, well-drained, loamy- sandy soils with a soil pH of 5.8 to 7.0, but they can tolerate a pH of up to 7.6 (Department of Agriculture, 2009). Fertilization greatly depends on the nutrient content of the soil, but it is important to note that beets will develop an internal black spot if boron levels in the soil are not adequate (Sanders, 2001). Table beets are typically ready for market between 50 and 75 days after planting; beets grown for processing are 1-4 inches in diameter while those distributed to markets are only 1-2 inches. The market beets are normally hand pulled and bunched in groups of 3 to 6 while mechanical harvesters are used for the processing beets. After harvesting, the tops are removed and roots graded, and then stored (up to several months) in crates or baskets at a humidity level around 95% to prevent shrinkage and temperature near 32°F (Sanders, 2001).

'Ruby Queen' and 'Redpack' are the most commonly grown cultivars, both of which are good for processing as well as fresh market. 'Ruby Queen' produces a smooth, round root with a small tap root. 'Redpack' produces a globe-shaped, dark-red root with short red-tinged tops (Sanders, 2001). Beets for fresh market usually produce around 7 tons per acre but good management practices can help produce up to 10 tons per acre.

Beets primarily grown for processing though should produce 13 to 15 tons per acre (Sanders, 2001).

Benefits

The beetroot provides a variety of dietary benefits: accounting for 1% of the daily needs for Vitamin A, 2% of calcium, 11% of Vitamin C, and 6% of iron (Ware, 2017).

Additionally, it is a rich source of folate and manganese. Both of which are very important for a range of important functions, including fertility, metabolism, skin and hair

growth, and bone formation (Ware, 2017). Other nutrients and minerals found in beets include nitrate, thiamine, riboflavin, Vitamin B-6, pantothenic acid, choline, betaine, magnesium, phosphorus, potassium, zinc, copper and selenium- all of which have a large range of health benefits.

Studies carried out in 2008 and 2010 found that blood pressure was significantly lowered after consuming beetroot juice, and other researchers found that beetroot juice can improve oxygenation to the brain which slows the progression of dementia (Ware, 2017). Beets have also been shown to help people with diabetes by lowering glucose levels. They also increase insulin sensitivity and prevent oxidative stress-induced changes in patients with diabetes (NIH, 2014). Improved digestion is another common benefit experienced by those who consume beets, because beets have a high fiber content. Enhanced exercise and athletic performance are yet another benefit of beetroot consumption. Beets have been shown to improve muscle oxygenation during exercise, which suggests that they have the potential to enhance exercise tolerance during endurance exercise. Lastly, the increased nitrate content of the beet is thought to be linked to preventing cancer (Ware, 2017).

Summary

Beta vulgaris is a vegetable that has made an impact on society for hundreds of years, from the beauty product of the 19th century to the the culinary star it is today. Beets have grown in popularity over the years and become a commonly consumed vegetable throughout the world. This may be due to the incredible number of benefits associated with beet consumption, or it may simply be due to the enticing earthy flavor

and bright color that they bring to a dish. Either way, this simple vegetable continues to make its name known globally.

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Tomatillo

By Austin Berrelez

The tomatillo (*Physalis philadelphica*) is also known as the Mexican husk tomato. This fruit has a variety of uses including soups, guacamole, salads and salsa verde. It is a warm season crop that originated in Central Mexico (Reed, 2018). Some believe that the tomatillo is a relative of the tomato even though it is not. However, it is part of the family Solanaceae.

Growing the Tomatillo

To get an early start when growing the tomatillo, it is best to start inside. Tomatillos become more drought tolerant as they get older, but tomatillo starts to require regular watering normally 25-38mm per week (Bell, 2014). This is helpful because the tomatillo is frost sensitive. Begin by sowing the seeds six to eight weeks before the last spring frost and plant them ¼ inches deep into small pots filled with potting soil. Tomatillos do best in well drained, sandy, fertile soil conditions with a pH between 5.5 and 7.3. They also require full sun exposure. After 1 to 2 weeks the seeds will likely have germinated. When transplanting make sure to place the plants in a sunny spot after all danger of frost has passed. Since most cultivars of tomatillos have a shrubby growth habit, they require ample space to grow. It is a good idea to space the plants 2 to 4 feet apart. Once the tomatillo is ready to harvest a thin papery husk encloses the fruit. If the fruit is stored instead of consumed right away it should be placed in temperatures above 41 degrees Fahrenheit because it is susceptible to cold damage. They will also continue to ripen if they are placed in a warm spot.(USDA,2016) Temperature requirements are 77-89 degrees Fahrenheit.

Pests and Diseases

Tomatillo plants are highly susceptible to early blight, cankers, late blight, tobacco mosaic virus and other diseases (Freeman,2012). Rotating crops and making sure to remove all diseased plants promptly will help ensure that there is a healthier crop.

Uses and Health Benefits

Tomatillos are primarily used for fresh consumption. They are often used in soups and salsas. These are mostly used in Mexican and Guatemalan dishes (Masabni,2015). Sometimes the fruit is preserved as a jam and or canned for later use. Like many fruits and vegetables, the tomatillo offers a variety of health benefits. They are a great source of dietary fiber, niacin, potassium and also manganese (Bell,2012).

Tomatillos contain on average 20% of the daily recommended value of vitamin C, 13% of vitamin E and a healthy amount of iron, magnesium, phosphorus and copper (Masabni,2015).



Origin

The tomatillo was first domesticated by the Aztecs in central Mexico around 800 B.C.E. (USDA,2016). This was an important food crop to many people in Mesoamerica, especially the Mayans. The name tomatillo (means “little tomato”). In Spanish, which is derived from the Nahuatl word tomatl. The Spaniards conquered Mexico and central America and in the 1300’s and 1600’s the plant was taken back to Spain where it was introduced to the people (USDA,2012).It was later found to be less popular than the tomato and therefore it did not spread throughout the region. In the early 1950’s tomatillos were introduced to India where it is

now locally cultivated. The fruit is currently cultivated in Texas for the most part because it is considered a weedy and invasive species in many areas of the United States. Outside of the United States the tomatillo is harvested in Mexico, Guatemala, South Africa and Kenya (Bernejo,1997). An exact dollar amount for the economic value of the tomatillo is hard to come identify. However, a marketing study conducted by the College of Agriculture Food and Environment at the University of Kentucky states, “In many states such as California, Florida and Kentucky, tomatillo farms have shown great market potential in areas with high Spanish populations, local grocery stores and restaurants specializing in Mexican or vegetarian dishes.”(Kaiser,2017)

The tomatillo is a versatile fruit that has travelled throughout the world. It has many health benefits in addition to being a delicious choice for a variety of dishes. It has shown to be popular in the United States’ Mexican community and as our population grows the tomatillo has slowly become a favorite food crop in America.

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White Asparagus

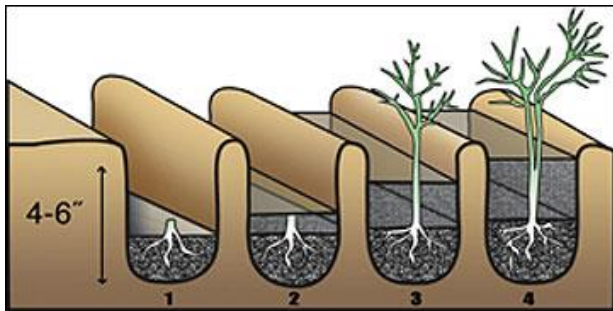
By Kelsi Campbell

History:

White asparagus is a unique springtime perennial plant, but ultimately is common green asparagus, or *Asparagus officinalis*, which is grown in specific conditions. It can be classified as a member of the genus, *Asparagus* in the *Asperagaceae* family (Editors of Encyclopedia Britannica 2018). The unique white color of any asparagus can be achieved through an agricultural technique called blanching. This technique utilizes darkness to stop production of green-colored chlorophyll pigments (Relf, 2009). The result is a white, tender asparagus. Typically, this plant is grown in sandy soils with a pH range of 6.0 to 6.7. Additionally, this crop thrives in areas with at least 8 hours of sunlight, sandy soil, and cool mid 60-degree weather (Relf, 2009).

Growth:

Asparagus is a perennial vegetable which begins its life under the soil, so the first step to planting is establishing crowns. Next is creating a deep trench which can be from 6-12 inches deep. Trench digging 12-18 inches wide helps produce the optimal space for growth and requires tilling of the subsoil for an additional foot down after this step (Relf, 2009). Trenches can be spaced 4-5 feet apart. The remaining soil should be mixed with organic matter and fertilizer or supplements



containing potassium and phosphorous. Planting begins by spreading a few inches of this fertile soil at the bottom of the trench and staggering plants. The asparagus crown should be covered with approximately 2 inches of soil every 2 weeks as

Figure 1: Trenches for asparagus growth with a focus on crown covering (mygardengeek.com)

they grow to maturity and the bed is level after around 6-8 weeks (Relf, 2009).

Asparagus is ready for harvest when it is 6-8 inches tall and begins to poke up through the surface of soil accumulated over weeks of mounding. This crop needs time to mature and establish itself, so harvest can wait up to three growing seasons or three years. Initial establishment occurs after one year of growth and after this period harvests can gradually begin each growing season. Blanching, which creates white asparagus, requires that the plants be continually covered after they break through the soil surface. This is done by mounding additional soil on top of the filled trench or bed to eliminate light exposure (Relf, 2009).

Consumption:

Blanching affects the chlorophyll produced inside the asparagus stalks and results in an asparagus crop of any cultivar which is noted for being more tender, less leafy, and mild in flavor. Another interesting fact about this crop is that asparagus comes in a variety of colors including white, purple, and green stalks. Blanched asparagus or white asparagus has the mildest flavor, and least fibrous texture when compared to green and purple cultivars. Green is the most commonly sold asparagus color and is known for a pungent savory flavor in combination with the most fibrous texture of the three colors. Purple, however, has the highest sugar content out of the three colors and contains less fibers than green asparagus (USDA, 2018).



Figure 2: "Three colors of asparagus from Australian Asparagus Growers."

Asparagus in general is a health beneficial food containing iron, folate, and calcium as well as vitamins A, K, C, E, and B6 (USDA, 2018). Other than its nutritional benefits it has properties for sleep improvement which are being explored in China. Asparagus powders are being created with concentrated levels of the naturally occurring chemical saponin. Studies demonstrate this

powder is likely to contribute to improvements in the reduction of time it takes to fall asleep, length of rest, and fewer sleep interruptions (Huang, 2017).

Saponin levels in asparagus have been assessed using dose-over threshold criteria to quantify the levels of compounds related to flavor observations as well. The bitter lingering taste in green asparagus can be attributed to the saponin levels in the plant. Cooked asparagus contain biodesmoside compounds, which help combat this bitterness (Dawid, 2014). White asparagus specifically has sweet notes of sulfur and butter which pair with its soft texture to form a crop used in a lot of upscale cooking (Dawid, 2014). However, it has been noted as a consumer problem that this food contains a bitter taste on its own, and studies have concluded this is due to asparagus saponin levels. These can be altered using breeding and plant growth techniques (Dawid, 2014).

Plant Structure:

Not all varieties are grown for their edible flesh, because some cultivars serve as ornamentals with wispy, fern-like, green foliage (Relf, 2009). Asparagus stems have modified leaves which are fleshy scales called cladodes, they are different than the foliage that asparagus produces (Relf, 2009). This plant forms a thick edible stalk and branches out to form soft, thin- pointed



Figure 3: "Fresh white asparagus - spring growth on cultivated fields. Image Credit: barmalini / Shutterstock"

modified leaf structures. Asparagus reproduces through the pollination of small flowers, which give rise to bright red berries, and eventually small black round seeds (Relf, 2009). Asparagus cultivars are dioecious, meaning there are separate male and female plants. Studies show that small variations exist between them which demonstrate

that female plants have heftier rootstocks and more weight per stalk, while males produce more stalks (Uragami, 2016).

Dangers:

In addition to its unique shape and structure, this plant has other interesting qualities. Asparagus has at least two endangered wild species, *A. fallax* and *A. nesiotus*. Known pests to most all



Figure 4: *Crioceris asparagi*, asparagus beetles gathering on the tip of a flowering asparagus.

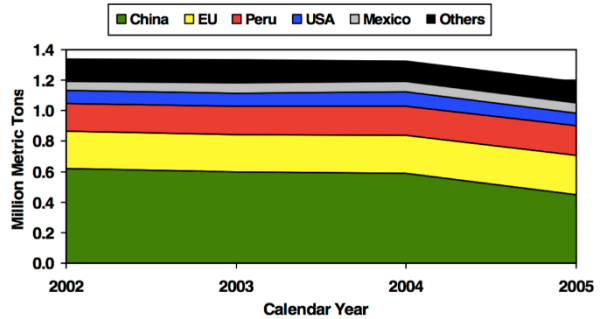
asparagus crops like these are cutworms, asparagus beetles, and slugs (Capinara, 2012). Asparagus beetles can be especially damaging to this crop in late summer to early fall, but many bio-control options are available including the introduction of the parasitic insect, *Tetrastichus asparagi* (Capinara, 2012).

Growers have issues with these persistent beetles because they have no natural predators in the U.S., which is likely a product of their European origin. They cause damage to asparagus shoots via chewing as adults and immature larva stages of life (Capinara, 2012). These beetles produce a black saliva-like substance as adults and chew to defoliate asparagus plants. It is known to stain asparagus growers' hands during harvest (Capinara, 2012). Damage to young shoots under the soil from insects and harvest can cause growth distortions and will render crops unmarketable. Post injury, asparagus plants grow away from the injury creating bends in the tissue and odd growth patterns (Capinara, 2012). Additionally, injuries cause an increase of the production of lignin and other plant compounds that create woody plant tissue. This plant therefore becomes increasingly fibrous and tough with more injuries (Dawid, 2014).

Economics:

China, Europe, Peru, Mexico, and the US are the largest producers of world asparagus production. Figure 5 shows that the United States alone produces approximately 1.1 million metric tons of asparagus. China dominates the market in production and can create an output of over 600,000 to 800,000 metric tons of asparagus per year. Asparagus grows productively in cool mid-range temperatures and grows best with periods of dormancy where it can build tissue in the stems and crowns. In the US, California dominates asparagus production but Michigan and Washington are also main producers/ exporters (USDA, 2018).

World Fresh Asparagus Production



Source: Food and Agriculture Organization (FAO) of the United Nations (all countries except

Figure 5: Worlds Fresh Asparagus Production in China, EU, Peru, USA, Mexico and others (USDA).

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Mesclun, Loose Leaf Lettuce and Assorted Mixed Greens

By Harley Combs



Recipes include directions for a simple mesclun salad as “whisk the lemon juice, vinegar and oil and mix with greens,” but what constitutes mesclun? Mesclun, the French word for “mixture,” describes various blends of loose leaf lettuce and baby greens. Also referred to as mixed or spring greens, an assortment of baby lettuce and other young greens and herbs are grown for the consumption of fresh tender leaves. All crops associated with mesclun are grown for the foliage, either as young leaves eaten as salads or as “braising mixes” for stir-fries. The purpose of this fact sheet is to define mesclun as a horticultural crop and educate others about its importance as a nutritional and an economically valuable crop.

Mesclun is a mix of tender greens consisting primarily of young loose-leaf lettuce (*L. sativa* var. *crispa*). Baby lettuces like ‘Cos’ or ‘Romaine’ (*L. sativa* var. *longifolia*) and other greens including mustard greens, young brassicas, and endives are common additions to mixes.

Domesticated lettuce is a member of the sunflower family (Compositae) believed first to have been cultivated around the Mediterranean. These greens are consumed fresh in salads, and most often preferred over heading lettuce for higher amounts of phytochemicals. Mesclun can include a wide variety of colors, textures, and tastes depending on the specific mix. (Reader, 2003)

Salad greens are popular worldwide, and lettuce is grown commercially in more than 20 states in the U.S. During 2015, the value of U.S. lettuce production totaled approximately \$1.9 billion, making lettuce the leading vegetable crop by value. Mesclun can be an interesting horticulture crop when used to raise the value of plated meals. The price for mesclun mixes hover around \$10 per pound. This price can be directly translated to the consumer through use of spring mixes for garnish. Due to the nature of the tender leaves, spring mixes may spoil during transportation. This tends to put mesclun mixes directly in consumer markets or being grown in backyard gardens.

Type of Salad Green	Characteristics
Arugula	Peppery flavor; sometimes called "rocket"
Beet greens	Slightly spicy
Collard greens	Salty and slightly bitter
Cress	Peppery
Endive	Slightly bitter
Herbs	Many varieties with flavors ranging from sweet to spicy
Kale	Can be slightly bitter; much sweeter if it goes through a frost
Lettuce	Many varieties in shades of red and green, with flavors ranging from very mild to earthy and even slightly bitter
Mache	Slightly sweet, mild taste
Malabar spinach	Hints of pepper and citrus
Mustard greens	Peppery
Orach	Similar to spinach
Pac choi	Delicate flavor between cabbage and spinach; sometimes called bok choy
Radicchio	Bitter
Sorrel	Tart, sour taste; use sparingly
Spinach	Delicate, mild taste; sweeter if it goes through frost
Swiss chard	Similar to spinach, but a stronger flavor
Tatsoih	Mild mustard flavor

Figure 6 Greens used for mesclun mix showing different characteristics
(Borgman2017)

Mesclun can be grown in a few short weeks with successive plantings and selective harvesting helping create a steady supply stream of mixed greens. Any tray, pot, or shallow dish can be used to grow mixed greens as long as there is adequate drainage. Raised beds allowing for drainage can be an improvement over heavy, clay type soils. Mesclun benefits from a rich, loamy- sand, well-drained soil, that is high in organic matter and loose in structure. Soil must be kept constantly moist, but not soggy. Water stressing plants with an already short lifespan causes them to become bitter and toughen.

Mesclun mixes grow best when pH is slightly acidic to neutral ranging from 6.5-7.0. Prepare beds by adding compost, working organic matter into top three inches of soil. Scatter seeds and rake in or cover with additional potting media. Spring greens are picked immature, and because of this can be planted closer together. This tight planting helps reduce weed pressure. Little pest pressure is common due to harvesting immature leaves. Damping off, a fungal pathogen common to seedlings, can become a problem if media or trays are reused without a sanitation step. To prevent issues with fungal outbreaks, use new media, wash and disinfect trays, and rotate crops grown in mineral soils.

When planting in ground, beds with long straight rows may cause seedlings to bolt or send up a flower stalk in an attempt to reproduce. The redirection of nutrients and change in plant lifecycle causes leaves to become tough and bitter. When discovered, plants with flower stalks should be removed. Fertilize with half strength nitrogenous fertilizer such as fish emulsion every six weeks. Mesclun mixes can be harvested when leaves reach heights of two inches. To prevent bruising and damaging plants, cut leaves free before reaching six inches. Successive plantings every two weeks allows for a continued harvest providing greens throughout an entire season.(Bailey 1997)

Salad greens by the numbers

Nutrient levels shown are for one cup of raw greens. Remember: it takes two cups of greens to make the nutritional equivalent of one cup of vegetables.

	Arugula	Kale	Romaine	Spinach	Swiss chard	Watercress
Vitamin A (IU)	237	1,598	4,094	2,813	2,202	1,085
Folate (mcg)	10	23	64	58	5	3
Vitamin C (mg)	1.5	19	2	8	11	14
Vitamin K (mcg)	11	113	48	144	299	85
Calcium (mg)	16	24	16	30	18	41
Magnesium (mg)	5	8	7	24	29	7
Potassium (mg)	37	79	116	167	136	112
Fiber (g)	0.2	0.6	1	0.7	0.6	0.2

Note: g = grams; IU = International Units; mcg = micrograms; mg = milligrams.

Source: USDA National Nutrient Database for Standard Reference. 2011

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Information on Specialty Tomato Cultivars for the Home Gardener

By Kyler Dale

Tomatoes, or *Solanum lycopersicum*, are a flowering plant from the Solanaceae family.

Technically, the tomato is considered a fruit in the botanical sense. However, the fruit of this plant is the part that people eat and is typically treated as a vegetable in the kitchen. The rest of the plant, stems, leaves and roots are not edible. The tomato is a warm season plant which means that this plant thrives in warm temperatures, preferably between 65 and 85 degrees F during the day, no lower than 60, as well as warm soil. Tomatoes are a very sensitive perennial and are usually treated as annuals. They are planted in the growing season and then replanted the next season. Today, the tomato is commonly found in grocery stores and farmers markets. Specialty tomatoes found in the grocery store seasonally and are typically sold at a higher price but the flavor of them is incomparable. Farmers markets generally have many heirloom varieties, which make a great addition to salads of many types or are equally as tasty with just a sprinkle of salt as a mid-afternoon snack. In this fact sheet we will explore the brief history of tomatoes as well as some cultivars of heirloom tomatoes.

The first documentation and description of the tomato was in 1554 by Matthioli in Europe (Bai and Lindhout 1085). It was mentioned along with the eggplant as a round and robust vegetable that starts out green and becomes a different color upon ripening. As a member of the deadly nightshade family many were weary to eat the fruits concerned that they were poisonous. Europe however, is not where the tomato originated. There is some controversy as to its exact origin though, it has been limited down to two likely places; Mexico and Peru. Interestingly enough, it was not originally noted as a food plant, “but rather as a curiosity with probable medicinal properties.” (Jenkins1948) The tomato was commonly called ‘Pomi del Peru’ and

‘Lycopersicon’ and the latter ended up as the genus. Scientists presume that the tomato was promptly taken from Mexico to Europe after conquest. The original documentations of the tomato do not show any sign of South American native language, therefore it can be deduced that the tomato did originate in North America, Mexico specifically.

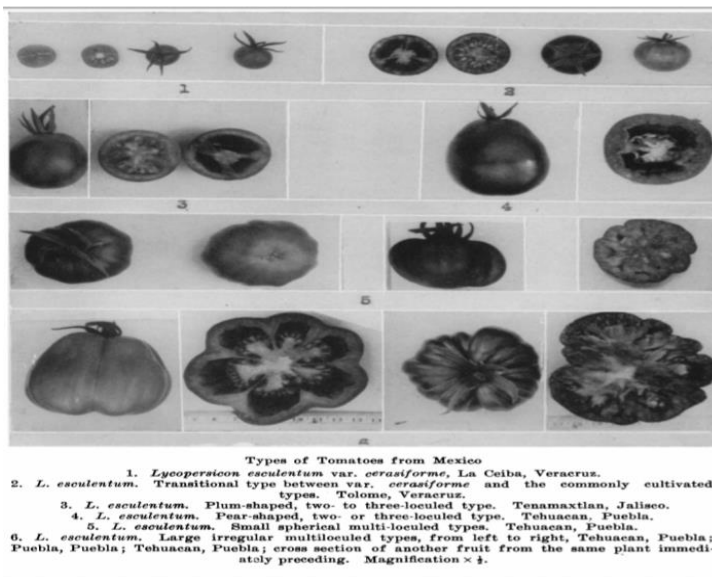


Figure 7: Wild tomatoes (Jenkins 1948)

So far, we have discussed the history of the wild tomato. As pictured above not all of those tomatoes are your classic round, red tomato that you would find at the grocery store. The size, shape, texture, thickness, etc of some of the above tomatoes look like heirloom cultivars however the differentiation did not take place until the late 1800s. Heirloom tomatoes were almost lost as the green revolution was picking up as well as WWII and people needed to make more food with more calories faster and easier. They needed hardy tomatoes that could be harvested while green and withstand shipping and also be uniform. This was accomplished by hybridizing many varieties of tomatoes. Luckily, small farmers and seed savers saved the seeds of these special heirloom tomato gems, relishing in the wonderful colors and flavors that these yummy fruits provide. There are many different varieties of this fan favorite fruit. According to

the Wiley Online Library (2007), “When people grow and save seeds, they join an ancient tradition as stewards, nurturing our diverse, fragile, genetic and cultural heritage. Our organization is saving the world's diverse, but endangered, garden heritage for future generations by building a network of people committed to collecting, conserving and sharing heirloom seeds and plant.” Truly heirlooms are practically an artistic treasure.

It is important to note that as mentioned above, flavor is the main reason these tomatoes have been saved for over 50 years. One issue with any heirloom variety is that it will be more sensitive than that of a non heirloom variety. Typically, the skin is much softer and thinner than on non heirloom varieties. They bruise easily and do not do well in transport from farm to store and then to table. These heirloom tomatoes are more likely to have scabbing on the bottom, as well as some cracking in the skin. Other than the aesthetics, these issues do not effect flavor and can be removed and the entire rest of the fruit should be unaffected.

The photo to the right is of a white currant tomato, *Solanum pimpinellifolium*. The fruit of this tomato species are very small. You could fit a few of these in a spoon as most of them are under an inch across. (rareseeds.com 2018) They have creamy yellow to whiteish skins and are extremely sweet. This species is vining and thrives when planted in full sun and typically turns a high yield.



Figure 8
(<https://www.rareseeds.com/white-currant-tomato/>)

This tomato on the right is called Berkeley Tie Dye. It was bred by Brad Gates of Wild Boar Farms in California. It has yellows, green, reds, and oranges as the name implies, in a tie dye formation on the fruit. The inside of the fruit is pinkish red in the center with



Figure 9
(<https://wildboarfarms.com/product/berkeley-tie-dye/>)

green flesh around the center. The fruit of this variety typically weighs from 8-12 ounces so it is rather large. Nevertheless, this is another extremely flavorful selection. (wildboarfarms.com, 2017)

A Russian cultivar of the tomato, the Black Krim, is an heirloom that will instantly catch your eye. Be it the deep maroon red color to almost black or the rich, bold flavor of tomato, most people cannot resist. Black Krim is one of four tomatoes that can withstand cooler weather although, if grown in cooler temperatures it takes around 50% longer to ripen. (de Juaregui 2017)



Figure 10 (<https://hirts.com/black-krim-tomato-30-seeds-russian-heirloom/>)

The ‘Brandywine’ tomato is another very popular heirloom tomato. It is a large beefsteak tomato known to have an exceptionally rich, succulent taste. It has been said that this tomato has the taste of an old-fashioned tomato. This Amish heirloom comes in a solid-red pink color and is one that can sometimes be found in grocery stores.



Figure 11 (<http://www.southernexposure.com/brandywine-sudduth-strain-tomato-bulk-size-15-g-p-473.html>)

The tomatoes pictured above are only four out of over 15,000 known cultivars. These tomatoes have withstood the test of time and because of their superb quality have been passed down generations. Heirloom tomatoes are something that can be grown, given the right climate, relatively easily by home farmers.

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Spinach, the Functional Food

MEAGAN ENGLISH

Spinacia oleracea is the scientific name for the spinach plant. Spinach is considered a vegetable because its epithet means “of the vegetable garden” (Missouri Botanical Garden-2018). The edible part of *Spinacia oleracea* is the leaves, which are commonly used in salads or as accents in a variety of food dishes. Leafy vegetable greens, such as spinach, are “recognized for their high mineral content, and recently, as ‘functional foods’ for their high composition of various beneficial non-nutritive plant chemicals known generically as phytochemicals” (Swiader and Ware-2002).

Spinacia oleracea belongs to the Chenopodiaceae family, or the goosefoot family. Plants in the Chenopodiaceae family have leaves that “bear a slight resemblance to the foot of a goose” (Armstrong-2018). *Spinacia oleracea* originates from Central Asia, but it has been “cultivated in Europe since the 1400s” (Missouri Botanical Garden-2018). The Muslims brought spinach to Sicily in 827 A.D. and then the leafy green traveled to Germany in the 13th century. Spinach made its way to England and France from Spain in the 14th century (Spinach History-2018). Spinach is thought to have been introduced to the United States around the 1800s (Swiader and Ware-2002). Spinach leaves are high in the minerals of iron, calcium, sodium and potassium, in addition the leaves provide Vitamins A and B (*Spinacia oleracea* – L.-2012). Spinach cultivars are classified by their seed and leaf type. The two seed types are prickly or smooth, and the leaf types are savoy (wrinkled), see figure 1 below, or smooth, see figure 2 below. The majority of the commercial cultivars are the smooth-seeded variety, which are much easier to plant correctly. For fresh market spinach, savoy types are often chosen, but smooth-leaved cultivars are typically used for processing.



Figure 12: Smooth-leaved cultivar ‘Corvair’ (Johnny’s-2018)



Figure 13: Savoy-leaved cultivar ‘Melody’ (Missouri-2018)

According to Swiader and Ware 2002, “spinach is the most important vegetable green grown in the United States, with significant commercial production for both fresh market and processing.” This is mostly due to spinach’s high amounts of vitamins and minerals. The minerals found in spinach include: manganese, folate, magnesium, iron, copper, calcium, potassium, zinc, protein, and choline. Another reason spinach is so important in the vegetable crop industry is for its phytochemical lutein content, “which has been associated with medicinal value for humans” (Swiader and Ware-2002). The total combined harvested acres of spinach for processing and fresh market in the United States is 35,377 with California producing seventy-five percent of the fresh market crop (Swiader and Ware-2002). Swiader and Ware put the value of the United States spinach crop at just over \$103 million. In comparison to China, which has \$5.7 billion dollar gross production value, the United States is not a world leader in spinach production (FAOSTAT-2017).

Spinach is an erect, annual herb that grows to maturity in about 30-50 days (Swiader and Ware-2002). Spinach is a cold-hardy vegetable that can overwinter in hardiness zones 8 and above if overwintering as a mature plant, or in zones 3 and above if the plant is allowed to die back. In general spinach can be grown as an annual in zones 3-9 (Growing Spinach-2018). See below for an image of the hardiness zones across America.

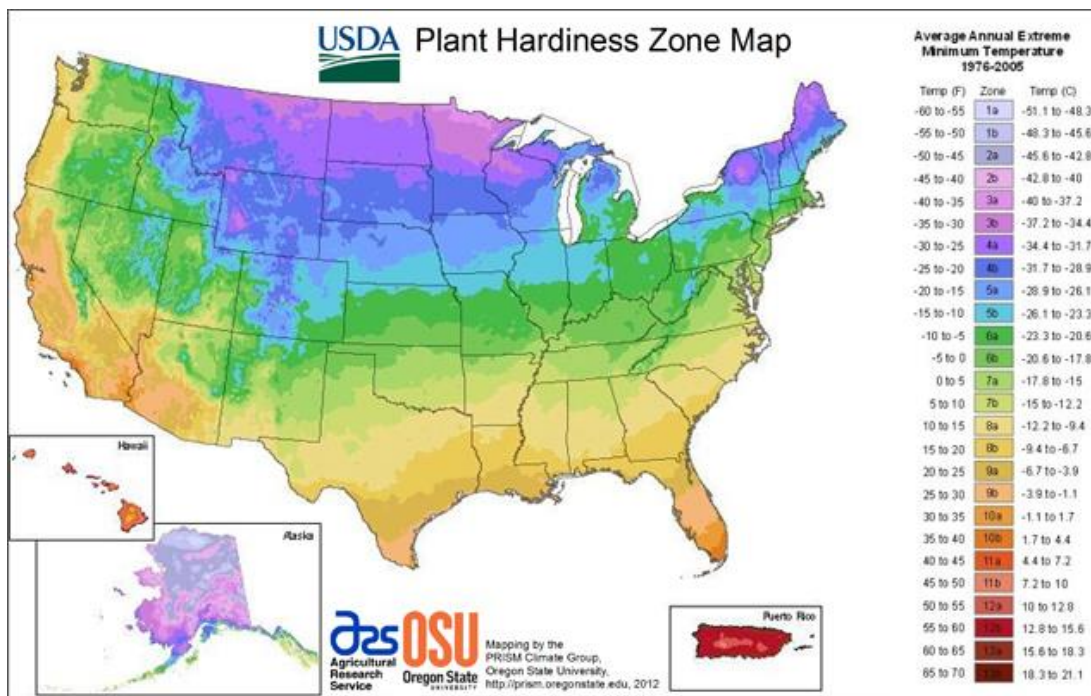


Figure 14: US Plant Hardiness Zone Map (USDA-2018)

The spinach plant is dioecious in that it produces male and female flowers on separate plants, however, some cultivars are monoecious. The dioecious varieties produce two different types of male plants called 'extreme males' and 'vegetative males' (Swiader and Ware-2002). For commercial production, the vegetative male is grown with the female plant because the vegetative male produces more foliage than the extreme male. For this reason, the extreme males have been almost eliminated from commercial production (Swiader and Ware-2002). During the vegetative phase, the spinach plant has a single stem around which the leaves are whorled, forming a rosette (see figure 4). The reproductive phase begins when the stem elongates and forms a flower-seedstalk, typically "in response to long days and warm temperatures" (Swiader and Ware-2002). When a spinach plant bolts or produces its flower-seedstalk, it loses its marketable value. Spinach is considered a long-day plant, which means that the photoperiod required for the plant to flower is based upon short night periods. The transformation from vegetative to reproductive is determined by temperature and is usually accelerated by exposure to low temperatures, 35°F - 45°F, followed by high temperatures, which includes anything above 75°F (Swiader and Ware-2002).



Figure 15: Botanical illustration of spinach (*Spinacia oleracea* - L.-2012)

Spinach grows best in a fertile sandy loam soil supplied with organic matter and ample drainage. The plant prefers full sun, but will tolerate light shade (Missouri Botanical Garden-2018). Spinach is sensitive to pH levels in the soil and will not grow well in acidic soils. "For optimum growth, the soil pH should range from 6.0 to 7.0." (Swiader and Ware-2002). Another soil characteristic that is important for spinach is the nitrogen availability. The nitrogen requirement for spinach is 60 to 125 pounds per acre, but "early spinach will usually require larger amounts of fertilizer than main-season or fall crops" (Swiader and Ware-2002).

Spinach is commonly directly sown into the ground or in raised beds "in narrow rows five to twenty inches apart at close in-row spacing of four to twenty plants per foot of row" (Swiader and Ware-2002). The wider spacing is used for hand cultivation while the narrower spacing is used for processing spinach. The spinach plant's roots are limited to approximately the top two feet of soil, making irrigation an essential component in cultivation. "The crop requires uniformly moist soil throughout the growing season to maintain continuous growth. Shortage of soil moisture very often magnifies the adverse effects of high temperatures" (Swiader and Ware-2002). Many of the weed problems that are involved in the cultivation of spinach include large-seeded broadleaf weeds, for which there is no effective herbicide

(Swiader and Ware-2002). Other issues for spinach include aphids, leaf miners, mosaic virus, downy mildew, damping-off, and fusarium wilt (Swiader and Ware-2002).

Spinach can be harvested when the leaves have reached an appropriate size, but before any deterioration to the leaves occurs (see figure 5). "The processing crop is usually harvested when foliage growth is at a maximum" (Swiader and Ware-2002). Processed spinach is handled



Figure 16: Harvesting spinach (Growing Spinach-2018)

in bulk and cut with machines. "For fresh market use, the time of harvest depends on the market, as well as on the size and condition of the plant" (Swiader and Ware-2002). Fresh market spinach is typically hand cultivated and sold in bunches. Many people enjoy eating baby spinach leaves for their size and tenderness.

In summary, *Spinacia oleracea* is a hardy vegetable that is easy to grow, nutritious, and an important part of vegetable production in the

United States. Spinach can be easily grown in a container, a raised bed, or on a commercial production level. The vegetable can survive in the cold as well as the warmth, but it prefers the intermediate temperatures of 50° – 70° F. The numerous minerals and vitamins that are found in spinach make the vegetable the ideal leafy green to include a variety of food dishes including salads, lasagnas, and even stuffed chicken. Spinach is an excellent addition to any garden, no matter how experienced the gardener is.

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Figure 3: "USDA Plant Hardiness Zone Map." United States Department of Agriculture, planthardiness.ars.usda.gov/PHZMWeb/.

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Dive into the Chive

By Jackson Fry

The chive, or *Allium schoenoprasum*, is a member of the Amaryllidaceae family and is closely related to onions (Petruzzello, 2016). Chives are commonly used in culinary cuisine to add a mild onion-like flavor and is common household herb/vegetable. Within the classification of being a vegetable, the pungent leaf of the chive is most often referred to as an herb because it is typically added for flavor and not eaten by itself. There has been a longstanding tradition of cultivating the chive in Asia and Europe that dates back roughly 5,000 years. The herb was used for its unique flavor and medicinal properties all over Europe, Asia and the Americas. Marco Pollo was the first to introduce the chive to Europe and it remains a commonly used herb (Mahr, 2011). Today, the leaf is the most commonly used part of the plant in cooking but, the flower can also be consumed or grown as a hardy ornamental perennial. I chose to write about the chive because I love to use them for cooking and I knew very little about how to grow them. This fact sheet will cover the world's largest producers of chives, growing and harvesting methods and common diseases and pests that effect the chive.

The mass majority of the world commerce created by chives thrives in China and Japan where the herb has been used for many a millennium in traditional soups, salads, entrées and sushi dishes. When examining the economy of chives, it is hard to find numbers that are specific



The leaf of the chive is the most commonly used part of the plant for its onion like flavor.

to the chive because they are just lumped in with the onion on the market reports. The most interesting information shows that China is currently the largest exporter of the herb, pushing 11.6 million tons per year (onions, chives and garlic). India and the United States are the second and third largest chive producing countries in the world (Nag, 2017).

For gardeners that are planning on growing this crop every year, the easiest method is overwintering the chives, as they grow prolifically through the growing season and are easy to



dig up and divide. As it is a cool weather crop, the ideal growing periods are spring and bulbs should be planted in fall. Chives grow in dense clumps of small bulbs that produce a hollow tubular leaf that extends 8-20 inches. The small blue-green leaves will emerge as early as March and continue through the end of the growing season. The small globe shaped inflorescence will bloom in late spring and early summer and consist of 10-30 star shaped florets that are typically purple or pink (Mahr, 2013).

Before planting chives, it is important to prepare the soil to create a rich, well drained, moist and fertile environment. They can tolerate a wide range of pH (5.8-7.0) and grow best in a loam soil, but can tolerate a variety of soil types. Be sure to plant them in full sun and they will produce the most in the cool seasons. If you want to achieve higher yields, apply a



high nitrogen fertilizer in May and July to improve output (Mahr, 2013).

When planting by bulb or sowing seed, be sure to separate the clusters 12-18 inches apart or follow the instructions on the seed packet as some cultivars may vary. After leaves have grown 4-6 weeks, they will be ready to harvest. Use a sharp pair of scissors or knife to cut the plant 1-2 inches above the soil. Be sure to harvest the outside leaves first and repeat harvesting frequently throughout the growing season as this will promote growth (Plant Village).

There are some common pests and diseases to watch out for when cultivating chives. As with many vegetable crops, it is important to not over water seedlings as they will become more prone to damping off. This is caused by a fungal infection that can be caused by the *pythium*, *fusarium*, *rhizoctonia* species. The seedling will appear to be healthy, and then shortly after sprouting it will collapse due to infected roots. To prevent damping off, be sure to not over water your seedlings to ensure the soil is moist but not saturated. There are also fungicides to help prevent damping off, but it is difficult to treat after the infection takes hold of the root system.

Another common fungal infection is downy mildew, which produces grey-purple fuzzy patches on the leaves that will turn them yellow and eventually kill the plant. If this occurs, apply fungicide and reduce watering around infected plants. Be sure to remove infected plant debris and avoid planting in this area the following year to prevent future outbreaks. The last fungal pest is an oomycete referred to as pink root that turns the root pink in color, then dark purple. This will make the chive



Pink root

appear to have a nutrient deficiency and stunt the growth of the plant. To prevent pink root

outbreak, rotate chives with other crops and do not plant in previously infected soil (Plant Village).

In regard to pests, the onion maggot and onion thrips are the most common insects to infest chives. Onion maggots are extremely damaging as they produce three generations every year.



Onion Thrips

The larvae are the most damaging stage as they feed on the roots and bulb of the plant. They can often be found tunneling in the bulb, so be sure to check the bulb if seedlings are dying off and more mature plants start to turn yellow. Control practices include rotating crops, removing the bulbs before winter and reducing water because they prefer a cool, moist environment. Granular

insecticides are commonly used on commercial operations, but should be avoided if possible (Plant Village).

Onion thrips will cause discolored, distorted tissue with yellow striations from their rasp and in severe infestations the leaves will have a silver hue. Pest management can be achieved through predatory mites such as pirate bugs or lacewings, insecticides which need to be applied as soon as possible and hard water spray as they are soft bodied (Plant Village).

Whether you are growing chives in your back yard or indoors, this is one of the easiest and delicious herbs to grow. More information can be found online at the CSU Extensions website.

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Muskmelon

By Linnea Goebel



Figure 1: Muskmelon (Go Botany, 2018)

A muskmelon may sound bizarre, but the vegetable commonly referred to as a cantaloupe, is more accurately named muskmelon in scientific literature (The Plant List.) Muskmelon is named for its sweet, aromatic, musky smelling rind when ripe. The terms are used interchangeably, although a cantaloupe is closer in nature to a cucumber-like melon. All cantaloupes are actually muskmelons, but not all muskmelons are cantaloupes. Known for its incredibly sweet, juicy flesh, this vegetable comes with health benefits and enjoyment from around the world. Calling something a vegetable that is as sweet as a dessert sounds incorrect, but it is indeed considered a vegetable. This is because, not only the way it naturally occurs in nature without human development, but also the close relatives which are more cucumber-like than the sweet melon that comes to mind.

The place of origin for muskmelon (*Cucumis melo* or *Cucumis melo* L. or *Cucumis melo reticulatus*) is from Africa, but some arguments are made that the true center of origin is actually Persia i.e. Iran (Texas A&M, 2018.) Although debate is still there, India, Japan, America and Iran are leading in production worldwide. Muskmelon was developed

through the ages from a bitter fruit to a honey-like tasting melon, typically served for dessert, breakfast or a healthy snack any time of the day. Usual characteristics are a medium or ice-box sized fruit, intricate webbing all over the rind, sometimes smooth, sometimes with indented ribs. Muskmelon usually has a bright, orange flesh with seeds in the middle cavity. Sometimes the flesh is light colored to almost green. The rind when ripe will produce a perfume scent, hence where the *musk* name comes from and will typically fall off the vine when ripe. The vine attaching to the melon will dry and allow the fruit to drop off from the plant (Mendlinger et al., 2008.)

Not only is it a sweet treat, but muskmelon is grown for other purposes such as seed production, seed consumption, melon oil, preserves and non-edible products such as natural fragrances (Mendlinger et al, 2008.) The flesh of muskmelon is a great source of vitamin A and C sitting at only 60 calories per 177 gram serving, usually 14 grams of sugar and 16 grams of carbs per serving (USDA, SELFNutritionData, 2018.) Vitamin A is an essential nutrient and is often severely lacking in some countries. This melon with its rich source of vitamin A and tolerance for many growing conditions could be a possible health enhancer in those countries which need that nutrient.

In some regions of the world, the close relatives of *Cucumis melo* are not eaten fresh from the rind, but rather the rind is pickled and eaten. The melon itself is cooked like other vegetables and eaten, or certain varieties have leaves which are cooked like greens. Of course those cultivars are the cucumber-like melons, not a sweet smelling, orange fleshed melon that first comes to mind. The sweet muskmelon flesh is eaten from the rind and in a lot of cases dried to be eaten year-round. Delicacies across the globe may be something common in your own backyard. While the muskmelon is

valuable enough here in the United States, a place like Japan will grow special muskmelons to be sold for anywhere from \$58 USD each and up.



Figure 2: Bitter Melon (boldsky, 2018)

Figure 3: Sapo Melon (Plant Finder, 2018)

Figure 4: Muskmelon (producemadesimple, 2015)

Figure 5: Snake Melon (Seed Empire, 2018)

Muskmelon is very tolerant of many different environmental conditions although, optimal growing conditions such as, lower elevations, hot and dry climates and lots of water to produce a high quality and abundant crop. Muskmelon plants are very sensitive to cold temperatures and will be killed by frost, and as they need lots of sunlight, too much can cause a sunscald on the fruits. Soil is one of the most important aspects of any crop, so the soil for muskmelon should be 6.0-6.5. It is best to ensure the soils are not too acidic for this plant since it is sensitive to non-alkaline or non-neutral soils. Susceptible to soil-borne diseases, muskmelon struggles without human help to survive these diseases. Muskmelon requires a lot of water, but at the same time there is a fine line between enough water and a perfect condition for disease. This is usually avoidable if muskmelon is planted preferably in well draining soils with fertile, organic matter. *Fusarium* wilt, downy mildew and powdery mildew are some of the most common soil-borne fungal diseases. Pests such as the melon aphid, whitefly, leafminers, and other

insects, cause great damage to muskmelon production. Damage is done directly by sucking phloem or chewing. Indirect damage is caused by the insect acting as a vector for a disease, usually a virus, which can in turn kill the plant (Mendlinger et al, 2008.)

Breeding programs that work with the diploid muskmelon do not typically focus on taste since the taste has been developed throughout many decades to the point it is widely accepted and enjoyed as it is (Garcia-Mas et al. 2012.) The size of the fruit, disease resistance, pest resistance, extended shelf life, drought tolerance and in some cases salt tolerance caused by either high salinity in the water or soil are all aspects of muskmelon are sought out to be improved through breeding.

Shelf life of muskmelon is very poor since the starches in the flesh break down at a rapid rate after harvesting. They are difficult to ship since they bruise easily and have the chance to rot at a fast rate compared to other vegetables. The difficulty of shipping this melon is the melon will not ripen after it is picked. If it is picked early in hopes it will ripen once arrived at the destination, it will just be a “cardboard” flavored melon. Meaning, it will not be sweet and juicy, it will be more like a unripe melon. If picked when ripe and shipped at cool temperatures, this can help extend the shelf life.

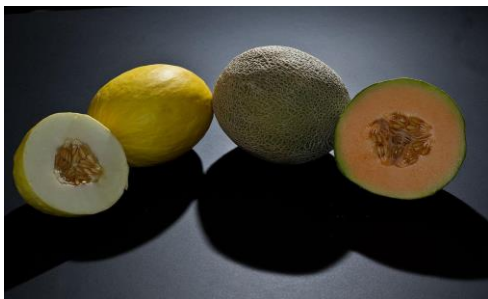


Figure 6: Muskmelon (Wikipedia, 2018)

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Cassava, the Other Potato

Mitchell Gore

Introduction

Manihot esculenta, or cassava, is a plant from the family Euphorbiaceae that is primarily cultivated for its large roots which are consumed as a source of carbohydrates (Plant of the Week: Cassava, 2007). The roots, comprised mainly of starch, are used as a source of food, flour, animal feed, and even ethanol production (Cassava (Manioc)). Horticulturally, cassava is considered a vegetable because it can be consumed as the main part of a meal with little to no processing (Uchanski, 2018). There are many cultivars/types of cassava which provide diversity in taste, color, and size.



Figure 2: (Harvested Cassava Roots, N/A)

Cassava is mainly grown and consumed in

Africa, South America, the Caribbean, Asia, and the Pacific. Its ability to grow in acidic soils, survive in periodic/extended droughts, and its high tolerance to pests makes cassava the ideal crop to grow in marginalized locations where farmers may lack the economic means to improve growing conditions. There is a long history of cassava cultivation and production dating back to 5000-7000 BC (Hillocks, R. J., et al., 2002). Not only does cassava provide a large global economic value, it provides nutrition and food security to millions of people around the world (Anderson, Leigh, et al., 2012).

Plant Background and Origin

Botanic Origin: The botanical origin (wild species descendants) of cassava has long been obscured. There were several wild species (uncultivated) of *Manihot* including *flabellifolia*, *pilosa*, and *spp. peruviana* that were previously considered to be cassava's parent material. However, genetic studies indicated their genomes (genetic makeup) were too distant from one another to indicate any ancestry. The study revealed that *M. triphylla* may be parent material (GP1) due to its similar genome (complete set of genes) but is still indecisive (Hillocks, R. J., et al., 2002). (*Manihot esculenta*).

Geographic Origin: It is believed that the geographic origin (area where evolution and divergence occurred) of cassava (*Manihot Esculenta*) comes from the Cerrado savannah in Brazil and then spread throughout the Amazon. However, it may have happened in reverse. Both the Cerrado savannah and the Amazon are relatively old types of vegetation which may hold the answer to Cassava's botanical and geographic origin. Both areas have experienced catastrophic disasters such as deforestation, fires, and floods over the last 100,000 years which resulted in the extinction of several species. It is possible that *M. Esculenta's* ancestors may have been one of these species. If the Cerrado savannah arose before the Amazonian forests, its biome (a large naturally occurring community of flora and fauna occupying a major habitat) may contain the answers regarding the ancestry of cassava (Hillocks, R. J., et al., 2002).

Agricultural Origin: Although the debate for cassava's botanical and geographical origin continues, there is a consensus that the plant was first domesticated for agricultural purposes 5000-7000 years BC by South American indigenous peoples which is supported by archeological findings. Cassava was cultivated in all neotropical areas well before Europeans arrived. It was

only then cassava was brought to Europe by the Portuguese and was distributed to Africa, Asia, and the Pacific. Modern cassava has a high level of success for vegetative propagation which makes it easy to grow on large scales. However, its wild relatives only have a 10% chance of survival when propagated because they are reluctant to produce roots well. Their small, fibrous root systems take several years to become big enough for consumption. This is a strong indication that cassava was selected for traits including higher percentage of rooting for vegetative cuttings, larger roots (for consumption), shorter period of producing large roots, and palatability. The domestication and selection process paved the way for modern day cassava (*M. Esculenta*) which is now consumed by millions of people all over the world (Hillocks, R. J., et al., 2002).

Where and How it is Consumed

Cassava significantly contributes to the nutrition and livelihood of over 500 million people world-wide.

Specifically, South America, the Caribbean, Africa, Asia, and the Pacific. Consumption has remained relatively

constant from 1983-1996 with consumption per capita

being the highest in sub-Saharan Africa. Flour, sweetener, animal feed, and medicine are some of the consumable byproducts (Cassava (Manioc)). Cassava leaves are also consumed in various ways. The Democratic Republic of Congo's vegetable output is 68% in leaves alone (Hillocks, R. J., et al., 2002). Data indicates that each region uses and consumes cassava differently. In Africa, 88% of cassava is produced for human consumption with 50% used as processed products. However, the Americas use 33% for animal feed while only 42% is used for human consumption. Cassava was introduced to Europe and Africa in the 16th century. It was not until



Figure 3: (Lopez-Alt, J. Kenji, 2012)

the late 18th and early 19th century where European explorers introduced cassava to Asia and the Pacific. Since cassava has spread to many regions of the world, there are endless ways to prepare the vegetable. For example, it can be boiled, steamed (Figure 1), fried (Figure 3), grilled, baked, processed, or even consumed raw (Hillocks, R. J., et al., 2002). The clear beads in tapioca pudding are products derived from cassava. They are generally tasteless so vanilla/banana pudding is added to increase flavor (Plant of the Week: Cassava, 2007).

Economic Value

Cassava has provided food security for millions of people across the world and because of that, sustainable global markets that hold large economic value were created (Anderson, Leigh, et al., 2012). Several industries have arisen from the versatility of the cassava plant (Figure 4) (Importance of Cassava, 2012). Although cassava has a large cultural significance in South America, Africa consumes and produces cassava in much larger quantities. This is due to market pressures of other major cash crops like maize, cotton, and soybeans (Hillocks, R. J., et al., 2002). The



Figure 4: (Importance of Cassava, N/A)

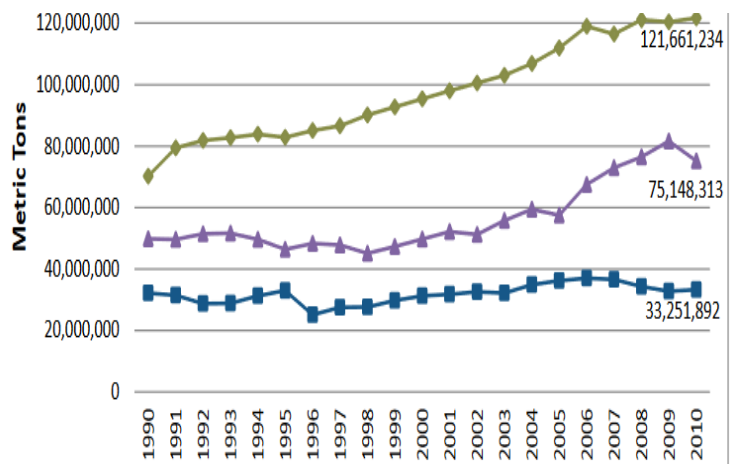


Figure 5: (Cassava Production: 1990-2010, N/A)

biggest producers in the South America are Brazil, Paraguay, and Colombia. Paraguay is the second largest consumer per capita next to the Democratic Republic of Congo. Africa produces more than the rest of the world (Figure 5) with Nigeria (35%), DRC (19%), Ghana (8%), and Tanzania (6%) making up the top producers in Africa.



Figure 6: (Tapioca Starch, N/A)

Asian and South American nations have taken advantage of producing modified starch from cassava which is largely exported for baking needs. Currently, Asian nations are the largest exporter of cassava goods such as animal feed and modified starches like tapioca starch (Figure 6)). The largest producers in Asia are Thailand, Indonesia, Vietnam, The Philippines, China, and Malaysia (Hillocks, R. J., et al., 2002).

Breeding, Production Systems, Harvest

Breeding: The objectives for cassava breeding programs are dependent to each region's local conditions and needs. The main institutions that have created cassava breeding programs are Centro International Agricultura Tropical (CIAT), and International Institute for Tropical Agriculture (IITA). For example, the cassava mosaic disease is prevalent in Africa so breeding for disease resistance is crucial for the livelihood of millions of people. In the Americas, the main objective is to create cultivars (cultivated varieties) that are well adapted to the seven climatic zones in South America. In Brazil, a landrace UnB400 is being bred for its high content of B-carotene (Nassar, Nagib, et al., 2007). Asia also breeds for cultivars that are adapted with-in the vast climates that they are grown in. In general, breeding programs select for higher yields, root quality (starch content), low cyanogenic glucosides (toxins), nutritional value, and disease/pest resistance (Hillocks, R. J., et al., 2002).

Production Systems and Harvest: Cassava is usually grown in low-input/low-output production systems. Seed propagation is feasible but not commercially viable because it takes longer to produce a mature plant than it does via vegetative propagation. Its also an easier to manage on a mass scale. Vegetative propagation consists of placing cut stems from the mother plant (vegetative propagation) 10-15 cm's in the ground which will produce shoots and roots. Each mother plant can produce three to thirty cuttings/stakes per year. Generally, cuttings/stakes are planted in ridges, raised beds, or mounds. Tillage is recommended as cassava needs loose soil for penetration of its fibrous roots. The density of cuttings/stakes varies from region to region due to ecological variables such as soil fertility, temperature, and moisture content. However, 20,000 cuttings/stakes per hectare is recommended (Hillocks, R. J., et al., 2002). Depending on the cultivar, the roots will be ready for harvesting after nine months to a year. The roots are severed from the mother plant and then processed for use (Cassava (Manioc)).

Conclusion

The botanical and geographical origin of cassava is still uncertain; however, a consensus has been reached on its agricultural origin. Indigenous peoples of South America (Brazil/Paraguay region) started cultivating cassava circa 5000-7000 BC (Hillocks, R. J., et al., 2002). Over several centuries, cassava has been selected for disease resistance, palatability, root size, plant vigor, drought resistance, better storage capacity, etc. to improve the overall quality of the plant. Cassava has been spread through-out the Americas, the Caribbean, Europe, Africa, Asia, and the Pacific (Hillocks, R. J., et al., 2002). Each region has different cultural and climatic factors that

dictate how and why the plant is produced and consumed. Its ability to grow in low-input systems allows farmers in marginalized areas to produce an economically viable product to sell on the global scale.

Modern molecular breeding programs have been created to continue the improvement of cassava and ensure future global food needs are met. As global populations increase, cassava will certainly continue to be cultivated for its high source of carbohydrates and its by-products in attempts to satisfy the increasing demand for food.

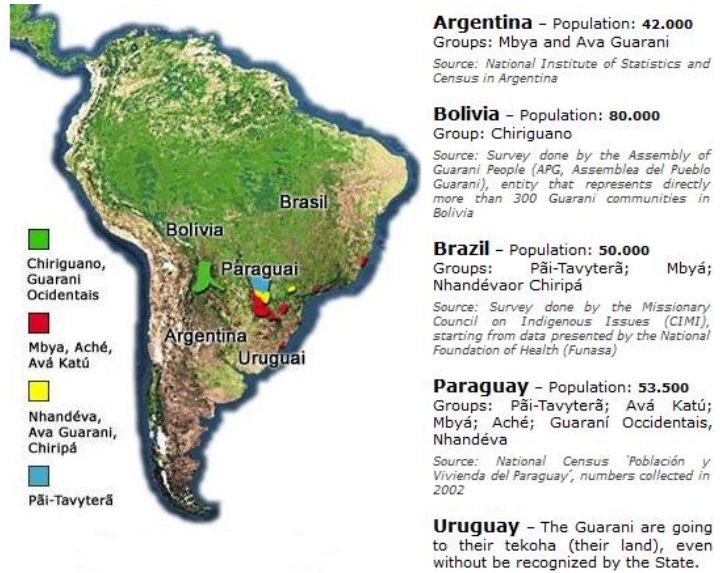


Figure 7: (Map of Guarani People, N/A)

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Summer Squash, the Common Denominator in Everyone's Garden

Hadassa Graham

HORT 480: Vegetable Crop Production

Colorado State University

Introduction

A common sight in most home gardens are some long and roundish looking fruits on a plant that has large leaves and seems to be trying to take over every other vegetable grown in the garden. In fact, it may have yellow/orange blooms, yellow/green/orange looking fruits, and some of them are huge! There is a good chance you have seen members of Cucurbitaceae, or the squash family (“Colorado Squash” 2015). This family includes many favorites like pumpkins, zucchini, yellow squash, and acorn squash. This fact sheet will focus on *Cucurbita pepo*, commonly known as summer squash.

The purpose of this fact sheet is to gain some more knowledge on this vegetable that everyone seems to have in their garden and explore what it has to offer to the culinary world. You may also be surprised as to how much squash is grown commercially in the United States. Fried crookneck summer squash is a favorite side dish in my family during the summer. This has inspired me to learn more about this amazing vegetable and share the enthusiasm for cooking with it.

History and Origin

Radiocarbon dating and evidence from archeological sites have dated squash back to 6500 B.C. from the lower regions of South America. (Swaidner 2002). It is likely that wild varieties were domesticated for specific uses, such as gourds to carry liquids and other useful items (Coter et al.

2010). As time progressed, squash varieties migrated north with trade and travel (Swaidner 2002). A cave in Mexico known for human habitation turned up squash seeds that pointed to possible cultivation of squash (Harrington 1997). Squash became an important part of Native American culture. A staple food across multiple tribes were the Three Sisters. The Three Sisters are comprised of three main crops: corn, beans, and squash. The corn provided a pole for the beans to climb. The beans provided nitrogen for the corn and the squash. The squash provided shade for the soil to hold in moisture (Park 2016).

This cropping system made its way across the continent of North America to the east coast. It has been documented that the Wampanoag Native Americans used the Three Sisters in their cultivation (Park 2016). It is believed that the name squash comes from the Massachuset Native American word *askutasquash* which means “eaten raw or uncooked” (Coter et al. 2010). This name hints at the why squash are classified the way they are, but more on this later.

This vegetable joins another famous vegetable in the debate of whether they are a true vegetable. In a botanical definition, summer squash produces a fruit because the squash itself is the product of a mature, fertilized ovary (“Frequently Asked...” 2017). Tomatoes, eggplants, and peppers are also classified as a fruit using this definition (“Frequently Asked...” 2017).

In the case of the tomato, the Supreme Court case of *Nix v. Hedden* (1893) ruled that the tomato was a vegetable rather than a fruit because tomatoes were used as a side dish or part of the main course of dinner and not eaten as a desert or sweet (“Nix...” 1893). This ruling is used to classify summer squash as a vegetable too because it is not typically eaten as a desert. If you do eat summer squash with your ice cream, please put a recipe online because there might be a lot of people interested about that practice.

Characteristics of Summer Squash

There are several different cultivars of summer squash. Stated earlier in the paper, the *Cucurbita pepo* species includes pumpkins, cucumbers, zucchini, winter squash, and summer squash.

While there are many similarities between all of these vegetables, there are quite a few differences as well. This section will focus on the production of summer squash. It is commonly thought that the

name of this vegetable refers to the season in which the squash was grown. However, the name actually refers to the period of when the squash fruit are eaten. (Swaidner 2002). Summer squash are typically harvested in the summer when the rind of the fruit is soft and fleshy (“Colorado Squash” 2015). The fruit of the squash plant is often picked before it reaches full maturity to ensure crop quality and flavor. The growing season of summer squash typically lasts from the last frost in spring to the first frost of fall (“Colorado Squash” 2015). The fruit is available as early as July to as late as October depending on when the crop was planted (“Colorado Squash” 2015). Summer squash often need 50 to 65 days until the first fruit is ready to pick and are known for their ability to produce in a short growing season (Basham 2014).

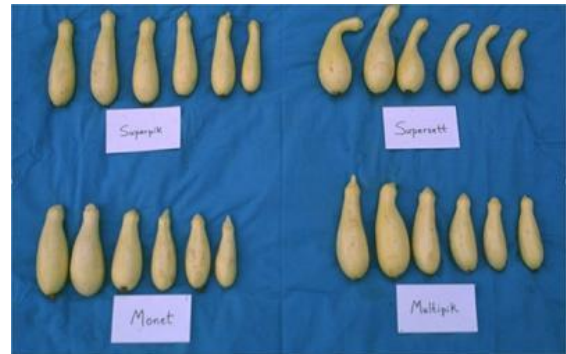


Figure 1: Some examples of straight neck and crook neck summer squash cultivars. Photo credit: Jonathan Schultheis, North Carolina State Extension Service 2005.

Summer squash has many different cultivars. There are zucchinis and cucumbers, which are similar to summer squash as far as growing season and care but produce a fruit that has different flavor and is used differently than summer squash. When most people think of summer squash, they think about yellow summer squash. Even in this small distinction, there can be crook neck and straight cultivars (University of Illinois 2018). There is not a distinct difference between the two besides the appearance. There might be a taste difference, but it can be totally up to the consumer as to which they prefer (Foster 2015).

Another fun fact about summer squash is that not only the fruit is edible; you can also eat the flowers (University of Illinois 2018). It is common to stuff the male flowers with a filling of some sort and lightly fry them in a batter (University of Illinois 2018). The



Figure 2: This picture gives a clear example of the different between male and female blooms. The one on the left is male. The one on the right is female with the difference being the ovary attached to the bloom that will later become a fruit if pollinated. Photo Credit: Steve Bender 2018.

reason it is important to clarify that male flowers are the ones that are used because the male flowers provide the pollen to fertilize the female flowers, which have the ovary to produce a fruit (“Summer Squash” University of Illinois). The difference between the two flowers on

the squash plant is demonstrated in Figure 2. A single squash plant will produce both male and female flowers, but pollination is required in order to produce a fruit (Johnson 2015). The pollen of summer squash is sticky, so windblown pollination is not common (Johnson 2015).

Honeybees and other flying insects pollinate the flowers (Johnson 2015). It has also been documented that there are two species of bees called *Xenoglossa* and *Peponapis*, or “Squash Bees” that are specially adapted to feeding on the pollen of various squash plants (Cane 2018).

The bees are found in southwestern United States and in the Southern Brazil in South America (Cane 2018).

Summer Squash Production in the U.S.

In addition to squash grown in personal gardens, it is produced commercially in the United States. According to Vegetable Grower News, the squash harvest totaled 5.82 million cwt for 2017, including both summer and winter squash (“3 States...” 2018). An estimated 35,000 acres were planted in the states of Michigan, Florida, New York, and Oregon (“3 States...” 2018). Summer squash in Michigan is ready for harvest after 50-60 days after planting and continues to be harvested in the field every 2-3 days (“Pumpkins, Squash, Gourds...” 2016). Regardless of where the crop was grown, the squash must meet one of the USDA quality grades: U.S. No. 1 or Grade No. 2. It is crazy to think that squash produced in the U.S. is grown on 35,000 acres total and provides much of the summer squash supply for the U.S.

The United States Department of Agriculture creates regulations and ensures that the rules are followed when producing agricultural products so that the products are safe and of high quality. Summer Squash has two main quality grades: U.S. No. 1 and U.S. No. 2. The definition of U.S. No. 1 is “squash of one variety or similar varietal characteristics, with stems or portions of stems attached, which are fairly young and fairly tender, fairly well formed, firm, free from decay and breakdown (USDA 2016)”. U.S. No. 2 is similar to this definition but has another level of maturity “firm” as the quality indicator instead of “fairly young and fairly tender” (USDA 2016). This does not mean the U.S. No. 2 is for old, nasty squash; both grades are concerned with the overall quality and maturity of the vegetable crop. Damaged, moldy, diseased, and discolored squash are disqualified from being graded and sold (USDA 2016). These quality grades from the

USDA ensures that producers get credit for the quality crop they produce and that consumers get a safe, high quality product for their dinner table.

For Your Own Garden

With so many fun facts about squash presented, you may have the urge to grab your garden shovel and start preparing a bed for your new favorite vegetable. Before you start, it is important to know different cultivars of summer squash so you can choose what characteristics and flavors you want on your table. For crookneck cultivars, some of the popular certified seeds include: ‘Tempest’, ‘Gold Star’, and ‘Yellow Crookneck’ from Jonny’s Seed Catalog (2018 “Summer Squash”). If you are interested in the straight neck cultivars, check out ‘Slick Pik YS 26’ and ‘Multipik’ (2018 “Summer Squash”).

Summer squash crops do well in Colorado so long as the danger of frost has passed. The length of the growing season is closely correlated with elevation (Basham 2014). Keep this in mind when you go to plant your favorite squash. The most typical practice of planting seeds are in “hills” or mounds, which are raised in the bed with furrows that allow water all the way around it (Basham). It is best to plant 5-6 seeds together in hills 4-6 feet apart in order to see success in germination and allow sufficient room for the plant to grow. Ensure the soil is moist when you plant the seeds and water as necessary once germination has occurred. As the drier months come, you may need to irrigate more as the growing fruits will require more water (Basham 2014). Once the fruits reach approximately 6 inches long and the skin is easily penetrated by a thumbnail, it is a prime time to harvest. A common mistake that people make is letting their fruits get too big which leads to a loss in flavor (Basham 2014).

Conclusion

Summer squash has been a summertime favorite of my family's. From fried squash to summer salads, the three crookneck squash plants we planted kept up with our demands all summer long. Though the plants grow quite large, they provide shade for other plants and bring color to your garden. The *Cucurbita pepo* species has a rich history and is a great addition to your garden. From the history of summer squash to how and where the squash are commercially grown in the United States, this paper has covered a lot of knowledge of summer squash. The hope is that this paper is informative and can be of use when you go to check out some seed for your next garden. Squash can become a family favorite, and there is a potential that your neighbor down the street may have even planted it in their garden too.

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HORSERADISH FACT SHEET

By Juniper Green

INTRODUCTION

Horseradish is a widely consumed specialty crop that is grown in Europe, the U.S., and the “hilly regions of India” (Swiader and Ware 2002, Wilson 2016). This fact sheet will address why horseradish root is considered to be a vegetable crop, how it came into cultivation, and what compounds give this crop a distinctive flavor. In addition, background information such as the origin, history, and the economic importance of this crop will be reviewed. Additionally, production, practices and cultivation will be addressed. Hopefully, these topics will allow one to understand the importance of horseradish as a specialty crop to the U.S. market, and promote a deeper understanding about what horseradish is and why it is consumed.

Horseradish is known scientifically as *Armoracia Rusticana*, which is a perennial vegetable crop (Swiader and Ware, 2002). Culinarly horseradish is considered to be a vegetable because of its pungent aroma and characteristic flavor, which is derived from the sulfuric compound allyl isothiocyanate (Swiader and Ware, 2002). Typically, the root



Figure 17: Horseradish roots and petioles, cut and laying on horseradish leaf (Stark bro's cited 2018).

is the portion that is harvested and consumed, the preparation of which is seen in Figure 1. The root is botanically the vegetative portion of the plant (Swiader and Ware, 2002). Traditionally the leaves were used medicinally and culinarily, although leaves are no longer commonly eaten (Swiader and Ware, 2002). Horseradish is one of the commercially marketed vegetable crops that is considered vegetative in both the botanical sense as well as the culinary sense (Welbaum, 2015). Most people consider vegetable crops to be those that they consume during meals that are not sweet and dessert-like but tend toward a savory inclination, rather than fitting the botanical definition of vegetative (Welbaum 2015). On both accounts, horseradish fits the bill.

Horseradish is a green herbaceous perennial with fleshy roots that have been cultivated for consumption or for medicinal purposes since ancient times, although specific dates are unknown (Swiader and Ware, 2002; Wilson, 2016). The roots are cylindrical and fleshy, white to slightly more yellow (Wilson 2016). Horseradish is a perennial however it is typically cultivated as an annual (Swiader and Ware, 2002). Still, there are some northernmost regions where the growing season is short enough that it makes sense to maintain the plant as a perennial and only harvest portions of the root annually (Straw, 2018). However, this is done less frequently due to the increased skill level required by growers to do so, as well as potential decrease in harvest volume (Straw 2018).



FIGURE 18: HORSERADISH ROOTS (SPECIALTY PRODUCE CITED 2018).

BACKGROUND INFORMATION

ORIGIN & HISTORY

A Armoracia rusticana belongs to Brassicaceae, otherwise known as the mustard family, likely lending to its nefarious pungency (Swiader and Ware, 2002). Horseradish is native to southeastern Europe where the roots and leaves were harvested and originally incorporated into folk medicine (Swiader and Ware, 2002). Its true center of origin is difficult to define because of the close relationship that the mustard family has with humans (Dixon, 2007). Humans have cultivated mustard family species since ancient and perhaps even Neolithic times, although exact dates remain uncertain (Dixon, 2007). Mustards are mentioned in ancient Greek and Roman literature but correspondingly date back much further to the *Upanishads* and other ancient texts (Dixon, 2007). For example, authors Dioscorides of Greece and Pliny of Rome wrote about horseradish, as well as various Renaissance authors among others, indicating that the ancient use of this herb was widespread and varied (Courter and Rhodes, 1969). The term horseradish likely comes from the Germanic term for the plant meaning “sea-radish” (Courter and Rhodes, 1969). It is believed that the German word for ‘sea’ was mistaken for an almost identical-sounding word that meant the toughness of an old horse (Courter and Rhodes, 1969). Thus, it is estimated that the name came from words implying that it was a very strong radish (Courter and Rhodes, 1969).

Due to high sterility/low seed viability rates and other factors, it has been suspected that modern cultivars of horseradish originated from an interspecific hybrid of unknown origins that have simply been vegetatively propagated for centuries (Straw, 2018; Courter and Rhodes, 1969). Yet, there have been many growers who have been able to propagate horseradish from seed, although the viability is low (Courter and Rhodes 1969). Therefore, natural crosses have been rare but are not impossible.

While horseradish is not considered to be an essential plant for sustenance, its growth was encouraged in Victory Gardens during the 1940s due to its ease of growth and flavor enhancing qualities (Meyfirth 1943). The

original article is represented in Figure 3 (Meyfirth 1943). Horseradish is favored as a condiment, especially because the pungency can be stopped at a desired level of heat (Straw, 2018). The addition of vinegar or other organic compounds can slow the volatility of the sulfuric compounds, namely iso-thiocyanate, that when exposed to air and gives horseradish its piquancy (Straw 2018). Many people love this flavor combination with their favorite meat or seafood entrée (Straw 2018).

A HORSERADISH CORNER
By LILLIAN MEYFERTH
New York Times (1923-Current file): Apr 18, 1943; ProQuest Historical Newspapers: The New York Times
pg. X17

A HORSERADISH CORNER

By LILLIAN MEYFERTH

WITH herbs taking a place in every Victory garden, and condiments becoming more popular and necessary to supplement foods, the horseradish may well come back to more prominence in home cultivation. It is not an essential plant by any means, but it is useful and a real addition to the table for those who like it.

Horseradish is extremely easy to grow—in fact, it requires scarcely any care at all and must be watched lest it become too rampant and spread over too large an area. It is an excellent plant to put in an unused corner of the garden where it may grow undisturbed.

The white roots grow long and hardy and are planted either in early Spring or Fall. Maliner Kren is the variety most extensively grown. The plant is propagated by root cuttings, not seeds, and the roots may be purchased from seedsmen. These are placed, tapering end down, in trenches or holes and covered with an inch or two of soil. If planted in Spring, the roots will be ready for use the following year. They are left in the ground over Winter.

In the Spring the roots are dug and the side shoots are taken off.

These are then used to propagate more plants. They are cut to about six inches in length, the tops with a straight cut and the tips with a slant, so that they are planted right side up.

Preparing the Soil

To produce the best horseradish, a well-prepared and fertilized soil is required. Rotted manure placed well below the surface will prove most satisfactory. Commercial fertilizer may also be added and dug well into the ground. Almost any soil will suit the plants except heavy clay, which will not allow the roots to develop, and light sand, which does not retain sufficient moisture.

To prepare horseradish, the roots are dug, finely grated and added to white vinegar (not cider). The jars are capped tightly to prevent spoiling and loss of flavor. The grated roots may also be added to mustard and catchup. For giving zest to oysters, sea food, roasts, salads and vegetables, horseradish is a real treat. A hot cream dressing for boiled beef is another favorite recipe.

Occasionally the plants will be bothered with flea-beetle, which feed on the leaves. These are readily controlled with lead arsenate.

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FIGURE 3: NEWSPAPER ARTICLE FROM APRIL 18, 1943 ENCOURAGING HORSERADISH AS A VICTORY GARDEN CROP (MEYFIRTH 1943).

IMPORTANCE

In my adolescence, I recall my father beckoning me over to where he stood in our Maryland backyard on a warm autumn day. As I approached, he held something up, cupped in his hands so I could not see, and told me to smell it. Suspiciously, I refused. He tried to get me to smell what was in his hand several times, but I held fast in my refusal. Grinning, he told me it was not that bad. “Watch,” he said, taking a big whiff. Not only did he stagger and fall to the ground, but upon attempting to stand many times subsequently he was so dizzy that he could only walk around in circles just to fall over again. When he finally regained his balance, I laughingly asked him what it was that he had smelled. He said, “I planted some horseradish.” I was still not compelled to smell the freshly pulled horseradish root, but I was nonetheless intrigued. After that incident plus trying horseradish myself in many dishes, it has become a favorite of mine. I often enjoy eating horseradish-based wasabi until tears roll down my cheeks. Thus, when it was time to investigate a crop for this report horseradish fondly came to mind.

Horseradish varies widely in its climactic adaptation, though it is not suited to warmer climates, which explains why it is grown mostly in northern regions (Straw 2018). The common states to cultivate horseradish in the U.S. are in Illinois, Wisconsin, California, Oregon, and New Jersey (Straw, 2018). This likely has to do with both cultural heritage and the settlement of eastern European settlers as well as the loamy conditions of the soils in these regions which allow for proper growth and harvesting (Straw, 2018). It is estimated that 3,500 to 4,000 acres of horseradish are harvested annually in the U.S., although the global market value of horseradish may be much greater than that of condiment sales (Straw, 2018; Pune, 2018).

ECONOMIC IMPORTANCE

The economic importance of horseradish as a culinary crop is significant. The leading countries in horseradish production are China and Poland (Tridge, 2018). Currently, the U.S. ranks 5th in production (Tridge, 2018). The global market for horseradish as a vegetable crop is \$617.5 million (Tridge 2018). Additionally, due to the scientific importance of the substrate horseradish peroxidase (HRP), the global market value for this substrate is \$38 million and is projected to reach \$73 million by 2025 (Pune 2018). While horseradish and enzyme itself is of little scientific value, the lab-created substrate is of great value. This market is technically separate from the market for agricultural production, as the specific processing is different, however it is still the market for a product made from the horseradish root. The growth of this separate market may lead to an increase in agricultural production.

SCIENTIFIC IMPORTANCE

Horseradish has made the news in recent years due to the discovery of its anti-carcinogenic properties and a greater understanding of how they work (Quinn, 2016). The Quinine reductase inducing activity of horseradish was studied and it was determined that higher grade horseradish crops have superior cancer-fighting abilities when compared to lower graded crops (Ku et al., 2015; Quinn, 2016). The United States Department of Agriculture (USDA) grades horseradish root according to three standards of quality as follows: U.S. Fancy, U.S. No. 1, and U.S. No. 2 in this respective order of descending quality (USDA, cited 2018).

The processing of HRP that is required to create this substrate lends itself to a completely different market from agriculture (Spadiut and Herwig, 2013). This substrate still has significant importance in the scientific community (Spadiut and Herwig, 2013). The industrial and medical applications of HRP have created tremendous breakthrough in these communities and may give way to future cancer treatment therapies and other biomedical advances (Spadiut and Herwig, 2013). HRP is a glycoprotein that is not present in the cells of most mammals (Garrett and Mellman, 2001). Therefore, it can be used in medical and biological research as a tracer in immunochemical studies (Garrett and Mellman, 2001).

BREEDING, PRACTICES & PRODUCTION

Horseradish is harvested for the root, although the roots and leaves were traditionally used medicinally in southeastern Europe (Swiader and Ware 2002). In folk medicine it was used as a diuretic and to help clear nasal passages (Shealy 1998). It was also thought to aid digestion and prevent scurvy (Wilson 2016).

Specific domestication is not well known (Swiader and Ware, 2002; Courter and Rhodes, 1969). Most of the cultivation in the U.S. is in the regions of Illinois and along the Mississippi River Valley (Swiader and Ware, 2002), but it has expanded to include other areas as previously mentioned (Straw, 2018). Many growers are long-established and have a firm grasp on their market holdings, so this makes it difficult to enter the market as a new commercial grower (Straw, 2018). Nonetheless, there are opportunities for local markets or the introduction of new products if they are derived (Straw, 2018).

Horseradish is propagated vegetatively from sets (secondary roots) that are approximately 6 to 18 inches long from the previous year's crop, which can be stored and replanted (Swiader and Ware, 2002). In this way, horseradish is planted/grown and harvested as an annual (Swiader and Ware, 2002). The sets are placed in 4 to 5 inch deep furrows and spaced approximately 18 to 24 inches apart (Swiader and Ware, 2002). They are cut with a slant at the bottom and a square cut at the crown to assist in proper root placement during planting, making it a labor-intensive crop (Swiader and Ware, 2002).

Once horseradish is established it is difficult to eradicate since it can regrow from any portion of the root (Straw, 2018).

CULTIVARS

The most common cultivars in production in the U.S. are 'Common', 'Big Top Western', 'Swiss', and 'Sass' (Swiader and Ware, 2002; Straw, 2018). These cultivars are most commonly used in commercial production, especially the latter two (Straw, 2018). 'Common' has broad, crinkled leaves and it is known for its high quality and yield, but it is susceptible to disease, particularly white rusts (Straw, 2018). 'Swiss' and 'Sass' are cultivars related to the 'Bohemian' which is known for smoothness (Straw, 2018). However, they are not as high yielding as 'Common' (Straw, 2018). 'Big Top Western' has high quality and yields, and it has disease resistance to the common white rusts but has a slightly rougher external appearance that is less desirable (Straw, 2018).

CULTURAL PRACTICES

Due to the higher value of straight roots, growers will often practice 'lifting' which is a process that involves pulling the plants up a few inches by the crown during the growing season (Straw, 2018). This process previously involved digging up the root and trimming away side shoots before replanting (Straw, 2018). As one can imagine, this process was labor intensive and time consuming (Swiader and Ware, 2002). Today growers use a metal rod to lift the plants a few inches by the crown, which is much more efficient (Straw, 2018).

Supplemental nitrogen is recommended in the quantity of 50 to 70 pounds per acre every 3 months during the growing season, but over-application of nitrogen causes root hollowing (Straw, 2018). If growing for certified-organic markets, ensure that nitrogen supplements come from organic sources such as bone meal or fish emulsion (Swiader and Ware, 2002).

Late season irrigation is recommended, particularly during dry periods, and has been shown to improve yields if utilized at specific intervals later in the season (Straw, 2018).

As for pest management, there are few pesticides or herbicides approved for use in either conventional or organic cropping systems (Straw, 2018). If growing in a conventional system one

could use pre- and post-emergent herbicides (Straw, 2018). However, most weed management approaches still often rely heavily on hand weeding (Straw, 2018). Organic systems rely primarily on hand-weeding and backhoeing (Straw, 2018). Since horseradish is a hardy perennial that regrows from small root portions, it is fairly easy to grow in conventional and organic systems (Peaceful Valley Farm Supply, 2012).

MARKETING & PRODUCTION

A region in southeastern Illinois' Mississippi River Valley known as the "American Bottoms" is the most productive horseradish area in the world and it has been in commercial production since the 1890s (Walters and Wahle, 2010). This area produces approximately 1500 acres of horseradish, valued at \$10 million, annually (Walters and Wahle, 2010).

While searching for marketing of horseradish and its products yielded few results, there still seems to be enough demand for horseradish products that they continue to stock our shelves (Walters and Wahle, 2010). Approximately 24 million pounds of horseradish are ground down annually to produce roughly 6 million gallons of horseradish product in America (Ross, 2012). At the current market value of horseradish of \$5.6/kg (Tridge, 2018), the American market value of horseradish can be calculated to be about \$296 million annually. Tradition seems to herald a high demand for this pungent-smelling and tasty root crop.

CONCLUSION

Horseradish root has been a tasty addition to American and European cultural dishes for many years (Swaider and Ware, 2002). While its origins cannot be certain due to the intense cultivation of mustard family members, it is clear that horseradish has been treasured by humans for much of recorded history (Swaider and Ware, 2002; Dixon, 2007). Horseradish has contributed greatly to the economy (Pune, 2018; Tridge, 2018; Ross, 2012), in addition to many scientific discoveries (Quinn, 2016). Many of our modern cultivars may have originated from few cultivars (Straw, 2018), but they are nonetheless loved and widely consumed. As a multi-million-dollar industry that seems to need little advertising, the significance of horseradish as a favorite American vegetable crop should not be overlooked.

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An Overview of Broccoli

By: Andrew Haler

The scientific name for the tree-like plant we know as broccoli, is *Brassica oleracea* var. *italica*. This green sprouting broccoli is one of two major varieties. The other is called *Brassica oleracea* var. *botrytis*, which is the white cauliflower broccoli (McMurray, 1999). Broccoli is the edible flower of an herbaceous plant, and is therefore considered a vegetable (Herbst, 2001). Vegetables are typically classified as an edible portion of an herbaceous plant, which are then grouped according to the part of the plant which is consumed. For example, we group together plants in which we eat the flowering portion, such as broccoli, edible stems, such as celery, edible roots, such as beets, edible leaves, such as spinach, bulbs, such as onions, and tubers, such as potatoes. According to the botanical definition, the fruit is simply the mature ovary of a plant. By this definition, there are many vegetables such as tomatoes and peppers that would fall under the criteria definition for a fruit. Fruits are typically classified by mature ovaries, which come from a woody stemmed plant, while vegetables are a vegetative portion of an herbaceous plant, (U.C. Davis Contributors, 2018).

Broccoli is a member of the Brassicaceae family, (formerly called Cruciferae) (New World Encyclopedia Contributors, 2007). This family is also more commonly referred to as the mustard family also called the cabbage family. This family of plants includes the following: broccoli, cauliflower, brussel sprouts, cabbage, kale, radishes, and collard greens. The four flower petals produced by this plant resemble the shape of cross. For this reason, the family was previously named Cruciferae, which means cross-bearing (New World Encyclopedia Contributors, 2007).

The cultivation of an ancestral cabbage, a wild ancestor of our current broccoli, is recorded to have occurred about 8,000 years ago along the coasts of Northern Europe Countries. These wild cultivars of cabbage were cultivated all over the Mediterranean Coast. Human beings gradually began to select for different characteristics domesticating various cultivars. All the different cultivars are among the same species of plant (McMurray, 1999). A cultivar implies a human cultivated variety of a plant. Human beings domesticated some cultivars of *Brassica oleracea* for tender, tasty leaves to be eaten, these cultivars became what is commonly known as kale. Other cultivars were selected for their large edible, tree-like, stem and flower head to be eaten. These cultivars were cultivated to become broccoli. Broccoli was originally an Italian vegetable, which was first recorded in France around 1560, (New World Encyclopedia Collaborators, 2007). Thomas Jefferson was among the first gardeners recorded to have grown the vegetable in the late 1760s. He grew them with a few other members of Brassicaceae, such as radishes and cauliflower (New World Encyclopedia Collaborators, 2007).

Brassica oleracea var. *italica*. has been bred to accommodate a variety of human desires. These include: the time it takes to reach maturation, the site of shoot production, size of the head, shape and appearance of the head, and disease resistance. The use of breeding techniques has allowed vegetable producers the ability to integrate the planting of early and mid-season cultivars for maximum yields and profitability. (Masley, 2018). Typical early cultivars range from 50-60 days to maturity, while the mid-season cultivars range from 60-75days. It should be acknowledged these maturity times are for transplanted broccoli, not directly seeded broccoli.

In figure 1, you can see an example the cultivar ‘Romanesco.’ This cross between cauliflower and broccoli has been bred for appearance and shape of the head. Breeders are also utilizing humans’ attraction toward beauty with this cultivar’s wonderfully spiraled heads (Masley, 2018).



Figure 1- Broccoli Cultivar ‘Romanesco’ (Specialty Produce Contributors, 2018).

Broccoli is typically marketed as a fresh product sold in grocery stores and farmers markets around the globe. This vegetable has more recently been marketed as a convenience item in the way it is prepared and presented. Broccoli now comes in steam-ready bags with pre-cut up florets. All you must do is poke a few holes in the bag then stick it in the microwave for a few minutes, and presto you have steamed broccoli. This form of product presentation is particularly appealing for busy parents with little time to cook, who would also still like to provide a nutritious meal for their children. The steam-ready bags are also marketed toward business professionals looking for a quick and healthy lunch. Another form of value-added marketing is pre-made broccoli coleslaw. Broccoli is also regularly sold as a processed product. The most common form of broccoli processing is to chop up the spears and freeze the broccoli for retail sales. For maximum nutritional benefits, it is essential to freeze the broccoli as quickly as possible after harvesting (Agricultural Marketing Resource Center Contributors, 2018).

Broccoli is a cool season vegetable which means the optimal growing temperatures range from 45-65 degrees Fahrenheit (Masley, 2018). The fresh-market production accounts for around 95% of the demand for this crop. California, which is an all-around powerhouse for vegetable production, is responsible for almost 92% of the broccoli production in the United States (Agricultural Marketing Resource Center Contributors, 2018). Although the crop is grown all year round in California, the biggest harvest time is from mid-October through December. Even though the majority of broccoli production is in California, broccoli is still produced in small quantities in nearly every state in the country (Agricultural Marketing Resource Center Contributors, 2018). According to the, United States Department of Agriculture, (USDA), in 2011 the United States produced 2,132 million pounds of broccoli. This staggering amount of broccoli heads was valued around 648,886,000 U.S. dollars, (United States Department of Agriculture, 2011).

Harvest time for broccoli comes when the buds on the head are well developed, hard and tight. If the florets of the buds begin to turn yellow, or begin to protrude and elongate upward from the main head, harvest the broccoli immediately. These indications are signs of bolting and flower production. It is important for harvest the head with at least six inches of stalk



Figure 2- Broccoli Harvesting (Adams, 2013).

attached. For optimal taste and nutritional benefits, harvest broccoli early in the morning. The heads are typically harvested by hands using a knife to cut the stalk of the plant. Broccoli should cut the stalk approximately 8 inches below the head at a slight angle (Old Farmer's Almanac Contributors, 2018). Figure 2 has a visual representation of a proper broccoli harvest with a slanted cut.

The importance of broccoli as a source of healthy nutrition cannot be overstated. The vegetable is incredibly high in Vitamin C, Vitamin A, Calcium, potassium, iron, and fiber, to name a few nutritional benefits (Allen, 2007). As far as vegetables go, many regard broccoli as a superfood, because of its wide-ranging nutritional benefits. Scientific evidence indicates pigmentation in vegetables correlates to nutritional value (Simon, 1995). In the case of broccoli, the darker the shades of the florets, the greater the levels of beta carotene and Vitamin C in the plant (Allen, 2007). A compound that naturally occurs in broccoli and other members of the Brassicas, called diindolymethane (DIM), is currently a widely studied area of research due to its anti-cancer benefits. This oil-soluble phytochemical is shown to have incredibly potent effects on enhancing the functioning of our immune system (University of California, Berkeley, 2007).

Broccoli is commonly consumed in a wide variety of ways, such as raw, steamed, stir fried, boiled, or in soups. For the best possible flavor and nutritional bioavailability, you should cook broccoli as soon after harvest as possible. The vegetable can be chopped and diced and added raw into salads, for a tasty crunchy additive. Broccoli slaw can be created by using the stems and grating or shredding them with a food processor (Allen, 2007). My personal favorite way to consume broccoli is by stir frying it with onions and lots of garlic.

I choose this vegetable crop, because it is one of my all-time favorite vegetables to grow and consume. Watching the massive stalk and leaves grow stronger and larger throughout the

season, I eagerly await the emergence of the green flower heads. Until about 4 years ago, I hated eating broccoli and most other green vegetables. As my taste buds matured, I grew to develop an appreciation for the bitter and savory flavors of this flowering plant. Using a knife, I get the privilege and satisfaction of cutting off the first head and major harvest of broccoli in mid-late June.

In conclusion, the vegetable *Brassica oleracea* var. *italic* is one of distinct economic, nutritional, and cultural importance. Different cultivars of this species have been consumed for thousands of years, and its consumption has spread across our world. Through breeding techniques, we continue to domesticate and generate new cultivars. Some of these cultivars offer us different nutritional benefits with their varied pigmentation (Simon, 1995). Other cultivars satisfy human desires for beauty and variation. Thanks to clever marketing and an increasing awareness in the nutritional benefits of broccoli, both the production and consumption of this vegetable crop have been increasing steadily for last few decades (U.C. Davis Contributors, 2018). Researchers continue to study nutritional benefits of various phytochemical compounds in broccoli (University of California, Berkley, 2007). If a person is seeking a vegetable with a wide range of culinary preparations and nutritional advantages, I suggest they begin planting different cultivars of broccoli.

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Ryan Hill

There are many different methods and practices when it comes to vegetable farming. No-till farming, is just one method the practice of not tilling the soil, usually allowing for a richer healthier soil (AP Environment). No-till farming is an important practice for sustainable agriculture and the future of farming. A cover crop can be used to keep nutrients in the soil and prevent soil erosion. They are typically planted in the off-season like late fall to winter. Another method that can be used is allowing old plant debris to decompose over time which puts nutrients such as nitrogen back into the soil. This article will demonstrate that no-till benefits are common in vegetable production due to low input costs, less weeds, and vegetable crop higher yields are a product of healthier soil.

No-till farming has been around for thousands of years (Spears, 2018). No-till farming became prevalent in the United States after the Dust Bowl. No-till was a good tool to fight the soil erosion and the negative side effects of the Dust Bowl. However, no till farming did not reach a commercial scale until the 1940s (Hagny, 2015). In the 1960s, no till farming was first mechanized by two Kentucky farmers. In 1985, a Farm Bill passed and government subsidies for soil conservation motivated more farmers to adopt no till methods. The number of no-till farmers, in the United States, increased to 6% by 1990. By 2004 that number rose to 22% and by 2016 35% of farms in America are no till farms (Hagny, 2015). No-till is also prominent around the world for example, South America uses mostly no-till for roughly 70% of its farms.

There are different methods for no till farming, but the overall concept is the same. To have a no-till farm it is important to start by doing a soil test and to identify what soil amendments are needed. Once you have your soil prepared it is a good idea to plant a crop like a legume (peas or oats) to get some extra nitrogen in your soil. Legumes can promote nitrogen in the soil from their roots creating a good healthy soil to plant in. Then you can go back and cut down the plant debris

and leave it on top of the soil to allow it to decompose. Leaving the debris on top of the soil reduces soil erosion and puts nutrients back into the soil overtime, as the plants use up the nutrients. It is important to have a permanent layer of crop residue on top of your soil to get the best no-till results. Crop rotation and cover crops are essential to a successful no-till system (Spears, 2018).



Figure 1:(AP environment, Chapter 11, no- till farming)

There is a common misconception that you occasionally till a no till system in the United States, but this is not the case. To have the healthiest soil it is best to let the crop residues and cover crops do their job and never till the soil. It is important to never till the soil in a no-till system. This is because when you till the soil you leave the soil bare thus resulting in soil that is easily eroded. Another negative to tilling your soil is that it disturbs the soil food web, and can even kill members of the that very important food web. Soils are made up of very extensive food systems. “Good soil is absolutely teeming with life...there is a whole world of soil organisms that you cannot see unless you use sophisticated and expensive optics,” (Lowenfels and Lewis, pg.19).

No-till is an important agriculture practice as we continue to deplete our resources, such as soil and water. No-till farming allows for less soil erosion, better absorption of precipitation due to slow evaporation, if done right higher crop yields, and healthy beneficial microorganisms in your soil (Greentumble editorial team). According to Derpsch, “He found that by the tenth-year net farm

income had risen from the CA farms from under \$10,000 to over \$30,000, while on conventional farms net income fell and even turned negative (pg.5).” This shows that not only are no-till practices beneficial from an environmental standpoint, but as well as an economic standpoint.

Figure 2 shown below shows the steps and benefits to having a good no-till system.



Figure 2: (AP environment, Chapter 11, no- till farming)

I chose to talk about no till farming because I believe that sustainable agriculture is essential to the future of farming and sustaining a healthy environment. No-till farming is a great option for sustainable agriculture and was a topic I wanted to learn more about and get other people to read about it as well.

The pros of no-till vegetable production include reduction of soil erosion, farmers save time and money, reduced fuel and equipment operation, water conservation, increases in crop yields, increases in beneficial insects and soil microbes, and high resource availability (Greentumble). Reduction in soil erosion leads to less runoff of water and chemicals and the farmer does not need to add as many fertilizers. An example of the need of less fertilizers can come from cover crops as well as crops like legumes that were previously stated in this paper. Farmers save time and money from not having to plow their fields. Due to not needing to till the soil leads to relying less on mechanical resources and more on mother nature to help keep the soil healthy. That is why the soil food web is so important because it keeps a healthy soil in balance if left undisturbed. The need to not till ultimately reduces carbon emissions from tractors and pollutants in the atmosphere. Water conservation comes from leaving the crop residues on the surface causing less evaporation and the soil can absorb and retain more water. Due to having a healthier soil composition with increased

biodiversity, no-till vegetable systems typically yield more (Derpsch). Not disturbing the soil by tilling allows for a healthier soil structure due to the beneficial soil microbes that help maintain a balanced food web within the soil. There is also a big movement of no-till farming happening around the world, in places like South America, parts of Asia, United States, Europe, as well as parts of Africa so the resources are very accessible. The cons include special machinery is required, not appropriate for every soil type, increase in herbicide use, no heavy grazing, nitrogen based fertilizers may still be needed, increase risk of plant pathogen exposure, increased herbicide application. Special machinery is sometimes required for no-till systems and it can be expensive. No-till is not appropriate for every soil type such as cold and wet soils, but there are always ways around this issue it's just a matter of building up the soil so that you obtain a desirable consistency (Ruen). There is also said to be an increase in herbicide use. No baling or heavy grazing can be an issue for some farms due to the need to maximize profits, but if your focus is vegetable production then it is more important to leave the crop residue behind instead of baling it up. The need for extra fertilizers can be fixed with being wise in the cover crops you just to plant. Plants like legumes fix nitrogen in the soil creating a natural source of nitrogen and eliminating a need to apply nitrogen-based fertilizers that may be harmful to the environment. Increase risk of plant diseases would be something that would just have to be monitored based on moisture levels in the field, if you have a good runoff system in your fields then this shouldn't be a big concern (Ruen). So, it's really a matter of whether you want to manage your crops using mother nature or pesticides/fertilizers, tilling the soil, and other conventional practices that in the long run have proven to damage the environment (AP Environment). There are some organic farms that use tillage and fertilizers to grow their crops but they are using organic substances as fertilizers which don't have as large an impact as a corn field would that has been sprayed with roundup.

Sustainable agriculture is something that needs to be taught more to farmers across the world. It is important that we work together to create a more sustainable food production system for future generations to come. No-till vegetable production is a great start to sustainable agriculture and could be a great solution to help reduce the rapid depletion of natural resources like soil and water and preserve farming for future generations. I am not convinced that it is the only or best solution however, due to other methods out there regarding sustainable agriculture. There would need to be a study done where they compare all the different types of sustainable agriculture practices in the same climate and soil medium to compare the results of plant health, yield of vegetables, overall cost/labor input, and environmental effects. This would be a costly study but worth in the long run to find which farming method truly works the best.

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Sweet Solanum (Tomatoes)

By Kelly Hogan

Solanaceae family member, *Solanum lycopersicum*, also known by the common name, tomato, is categorized as a fruit because of how it reproduces. However, in 1893 the supreme court ruled it to be a vegetable under U.S. Custom Regulations (NPR-2013). The first tomato came from what we know as Peru. Wild tomatoes can still be found in the Andes there. The first refined tomatoes were yellow and about the size of a grape (Sim et al.-2011). These first tomatoes were once believed to be poisonous. The tomato is a part of the solanaceae family or known as the night shade family, which includes potatoes, eggplant, tobacco and many more common plants (Särkinen et al.-2013). Many of these plants possess alkaloids. In high quantities, alkaloids can be extremely toxic. Certain parts of these plants can contain more alkaloids than other parts. This gives reason as to why the first tomatoes were believed to be poisonous (Christou et al.-2017).

The tomato began as being a plant no one dared to eat because of its resemblance to deadly nightshade. The two had been mistaken for each other enough times that no one dared to chance it. When the tomato made it over to Europe, the wealthier Europeans admired the tomatoes beauty but did not eat much of it because they thought it was poisonous. The poor in Europe ate lots of tomatoes though and were completely fine. This was because the wealthier Europeans ate off plates and silverware made of pewter, which has a high lead content (Christou et al.-2017). The acid from the tomatoes would make the lead leech out and the Europeans would ingest the lead, which would sometimes induce lead poisoning.

The tomato is one of the more widely consumed fruits in the world, there are many uses for the tomatoes in cooking. It is used in numerous foods, such as ketchup, pasta sauce,

salsa, and juice. It can be pickled, fried, chopped up, used in skin cleansers, and even used for sunburn relief. The wild tomatoes we domesticated years ago, look nothing like the tomatoes we eat today. Originally, they were only about a centimeter wide, green, and very hairy. They were considered to be bitter (Baldantoni et al.-2016). It is estimated that the tomato was domesticated before the year 1500 by North Americans. The first domesticated tomatoes were said to be large, ribbed on the outside, and yellow in color. Not long after the first domesticated tomatoes were founded, many other varieties began showing up. These tomatoes were in all sorts of sizes and colors, not just large and yellow. Today there are more than 10,000 cultivars of tomato plants in the world like the 'Early Girl' or the 'Better Boy'. The average American consumes 28.3 pounds of tomatoes every year (Dai et al.-2017).

Around the world people were convinced that tomatoes were poisonous and/or a hallucinogenic. This caused a demand for the cultivars of tomatoes that were rumored to be hallucinogenic (Trebolazabala et al.-2017). Hemlock, nightshade, henbane, and mandrake, for example, have hallucinogenic properties. The hallucinogen from these plants are supposed to make you feel like you are flying. The tomatoes' similarity to deadly nightshade is uncanny, the plants are similar in several morphological features (2017). Although tomatoes are edible, it is hard to tell the difference between yellow cherry tomatoes and mandrake fruit. In the figures below the fruit on the left is the mandrake fruit and the one on the right is a yellow cherry tomato.



Figure 1. Mandrake Fruit (Symi 2015) Figure 2. Yellow Cherry tomato (Shneor 2018)

<http://symifloraandfauna.jigsy.com/entries/general/fruits-of-mandrake>

<http://www.shneorseed.com/?q=portfolio-3-cols/Cherry-tomato>

Temperature can affect tomatoes growth immensely. The actual temperature at which freezing will occur depends on such factors as plant species and variety, plant vigor, soil conditions, surface cover, duration of the freezing temperature, thawing conditions, cloud cover, and wind conditions. In tomatoes, freezing causes a darkening of the leaf or stem tissues (Dai et al.-2017). Damaged areas later wilt and turn brown. It may be difficult, initially, to determine whether the growing point has been killed and damage may become more obvious on the day after the frost. Tomato plants were originally from the tropics, so they are adapted to warm weather, so when cold weather hits them they die (Dai et al.-2017). This is why in some areas of the world the tomato is considered a perennial and where we live it is an annual. It cannot withstand the cold temperatures we get here but in

other places of the world where it does not get as cold it can stay alive for longer.

Tomatoes require a lot of water to grow successfully. Fertilizers can be used but only during certain stages of the growing period for best results (USDA-2013). Tomato plants can be affected by numerous different pest species and diseases. The most common pests are aphids, cutworms, and many others. All have different solutions on getting rid of or even preventing them in the first place (Dai et al.-2017).

The tomato industry in the United States is one of the worlds leading producers. The fresh and processed tomatoes make up about \$2 billion in annual farm cash receipts (USDA-2013). California is the leading producer of tomatoes in the U.S. producing 96% of the processed tomatoes. The processed tomatoes are for things like pizza sauce and tomato soup. Virginia and Georgia are the top two producers for fresh market tomatoes (USDA-2013).

There are over 10,000 cultivars of tomatoes that can come in colors like black, green, red, pink, yellow, purple, and orange (USDA-2013). As long as this crop is taken care of it will reward you with the delicious fruit it produces and you will not have to worry about being poisoned. I chose the tomato for my topic because they are one of my absolute favorite foods. I eat the big ones like apples and the small ones like grapes. I have grown many different cultivars myself and have figured out the ones I really like. They are such an delicious vegetable and I find the history of them to be very interesting. I will continue to grow tomatoes in all shapes, sizes, and colors as long as I still have a place to put them.

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Brussel Sprouts

By Theodore Huckestein

Introduction

Brussel sprouts or *Brassica oleracea* get their name because they have been grown in Brussels, Belgium for as long as people can remember (Anderson, Martin). It is considered a vegetable because we pick the small heads, “sprouts”, that form at the leaf axils and eat them after harvesting. The sprouts look like mini cabbages and can grow from the base of the stem to the top. They are considered a gourmet vegetable and have a mild flavor. “In the United States, 90 percent of the commercial crop is produced in California where it is grown primarily for eating” (Swaider, 2002), although today there is an increasing demand for fresh Brussel sprouts and the number of frozen Brussel sprouts has gone down.



Figure:1 Brussel Sprouts

Cultivars

Brussel sprouts can grow from a little more than a foot tall to over three feet and can vary in days to maturity from 75-120 days. With the taller plants having less sprouts on them and longer spaces in-between nodes there is less of a chance for disease to occur. There are many brussel sprout cultivars but as Hamson describes “Practically all of the brussels sprouts grown in the U.S. are hybrids of two main cultivars: The Jade Cross hybrids and the Prince Marvel, or the Captain Marvel hybrids. The Jade Cross hybrids are one of the best choices for home gardens in short-season areas.” While the Jade Cross might be a shorter plant it produces better than the

taller Prince Marvel has less chance of getting rot because of the greater amount of air space around the plant. Brussel sprouts can also come in a purple color with some cultivars being 'Ruby Crunch' and 'Red Bull'.

Culture

Brussel sprouts are a cool season crop and need a long cool growing season with mature plants being able to survive temperatures well below freezing. Transplants are commonly used to accommodate a short growing season. The cool



Figure:2 Pile of Purple green Brussels Sprouts

temperatures are important because they help keep a compact bud during its development. If grown at higher temperatures the sprouts can become puffy and soft. In Colorado there are many good places to grow brussel sprouts with the springs and falls and is recommended to use transplants.

Soils

Brussel sprouts have to be grown in cool temperatures, but the soil can also effect the plants "Brussels sprouts require a minimum of six hours of sunlight each day. The soil brussel sprouts grow best in is a fertile, well-drained, organic soil but will tolerate a wide range of soils. Brussels sprouts grow best in a soil that has a pH of 6.2 to 6.8." (Westerfield). Brussels sprouts are not best suited for soils with heavy clay or poor drainage. The soil should always be fertilized before planting to ensure nutrients are available with 1 tablespoon of ammonium nitrate per 20 feet about three weeks before planting.

Fertilizing

Brussel sprouts should be well fertilized before planting, during growth, and into maturity to fulfill the nutrient requirements of these heavy feeders. “About half of the nutrients taken up by the crop are removed during the first two-thirds of the growing season” (Welch, 2014).

Fertilization will have to occur many times throughout the season with a later addition of boron, which is a micro nutrient needed to develop good brussel sprouts. To keep plants producing an application of nitrogen every three to four weeks is needed.

Irrigation

Brussels sprouts like moist, not soggy soil with needing about one to two inches per week. Drip lines working best, however they do not rinse off residues from insecticides or herbicides. Mulching can help in weed suppression and soil moisture when applied to the beds of brussels sprouts.

Pests/Diseases



Figure:3 Ahipds on brussel sprouts

Brussels sprouts can get a range of pests from aphids, earworms, cutworms, and beetles among others with the most common problem being aphid damage. To get rid of aphids “a forceful spray of water directly on the aphids will knock them off, once they have fallen to the ground most will not be able to climb back up

on the plant. Use the water jet option first as it is the least invasive.” (Contra Costa Master Gardeners, 2014) You could also use store bought premixed insecticides, but these will be more

invasive and can leave behind residues. If these premixed insecticides are not used properly than runoff can occur leaching the chemicals into native habitat, negatively affecting the plants and animals surrounding were it was used.

Some diseases Brussels sprouts can get is black rot, downy mildew, and *Alternaria*. The best practice to ensure the plants do not get a disease is to make sure there is plenty of air circulation in the plants. If the plants are grown too densely then the lack of air circulating can grow diseases.

Harvesting and Consumption

Brussel sprouts produce small heads from the bottom of the plant up. When the lower sprouts are around an inch in diameter, the top can then be cut off about an inch from the top to encourage the top heads enlarge. You can also continually harvest the sprouts “ When harvesting, pick sprouts when green and hard (or purple and hard) and approximately 1-2 inches in diameter, slightly smaller than a golf ball. Break away the leaf just below the sprout then snap the sprout off. Leave smaller sprouts on top of the stem to further mature.” (Rose, Linda, 2018). Once harvested the brussel sprouts can be pickled or frozen for longer storage or they can be eaten raw.

There are many ways to use your brussel sprouts from steaming, sautéing, to baking. They can also be used as a substitute for cabbage in almost any recipe, personally have made brussel sprout sauerkraut, brussel sprout kimchi, and fermented brussel sprouts. They work so well as a substitute for cabbage because they are a cultivar of cabbage. People are put off by brussel sprouts because they are used to only eating them steamed and over cooked but with all the

different ways they can be used they have much more potential than people think and should be used more. This is the main reason I wanted to research brussel sprouts because I know how good they can be when properly grown and prepared.

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Enigmatic Endive

By Bridger Jackson

Endive, *Cichorium endivia*, is a leafy green, cool season crop from the family Compositae (the sunflower family) which is grown in a similar manner to lettuce. Endive is typically eaten in salads with a mix of lettuce and other greens, the endive serving as a flavor accent and adding “sharpness” to the taste of the other greens due to the slightly bitter flavor of the endive’s darker outer leaves. Endive is considered a vegetable, in the horticultural sense of the word, because it is almost elusively eaten with or just before the main course, it would be hard to believe that anyone would choose to eat endive for dessert. To ensure optimal flavor, the dark green outer leaves of the endive are often loosely tied up overhead of the inner leaves, thus excluding light from the young inner leaves providing a blanching effect and mellowing the natural bitterness of the endive. Endive’s recorded history is slightly controversial; according to Prohens-Tomás endive likely originated in Indonesia or Egypt, however, a number of publications credit a Belgian farmer by the name of Jan Lammers with the accidental discovery of the widely popular Belgian endive (The Story of Endive, 2010).

Endive is produced using almost exactly the same methods as lettuce, according to Ryder. Optimal soil conditions for endive growth are high water content, slight acidity (pH from 6.5 to 7.3) and low salinity. Soil should also not be too sandy, as this will likely cause tip burn due to sandy soil’s tendency to stay warmer for longer and a lower rate of water retention (Ryder, 1999). Heavier soils such as peat or even clay are ideal for endive growth. This crop has a fairly high tolerance to heat, it can survive temperatures up to 80 degrees Fahrenheit without tarnishing the quality of the produce; however growth will be

most ideal at cooler temperatures ranging from 65 to 75 degrees Fahrenheit. Excessive heat will cause unwanted bitterness in the edible leafy greens in the same manner as lettuce, though endive can withstand slightly higher temperatures. Typically, soil on which endive will be grown is tilled just prior to planting, this is critical because soil with a large amount of clods or a thick surface crust will make it difficult for cotyledons to emerge. Similar to lettuce, endive is typically ready for harvest about 90 days after planting, certain limiting factors like extended periods of cool weather can affect the rate of growth of this leafy vegetable (Nolte, 2006).

China is the world's leading endive producer with over 50% of worldwide growth at just under 15 million tons produced yearly. The United States is the next largest producer of endive at 4 million tons of yearly production, followed by India at just under one million tons (Food and Agriculture Organization of the United Nations, 2007). Endive is typically grown and harvested with lettuce and other leafy greens, the previously listed statistics may be skewed due to growers lumping all their leafy salad green crops into the same category when reporting yields. Little information is available regarding the economic value of endive in the United States, many publications list endive, escarole and chicory under the same statistics. According to the Handbook of Plant Breeding, the United States imported 8 million dollars worth of endive/chicory in the year 2002. Endive is far more popular in European countries than it is in America, Italy being the chief consumer of the vegetable.

Jan Lammers, a Belgian farmer is credited with the modern "discovery" of the popular Belgian endive; sometimes referred to as escarole, a bitter, tightly bunched, broad leafed cultivar. According to The Story of Endive, Lammers stumbled across this vegetable sprouting in his cellar which he had been using to store chicory roots to be used

as a coffee substitute. After some time in the damp, dark cellar, the roots began to take hold and produce the leaves which are now known as Belgian endive. When Lammers returned to his cellar, he discovered the sprouting vegetable and opted to sample it (The Story of Endive, 2010). Upon sampling this strange new vegetable he took pleasure in the odd bitterness of the bunched leaves and decided it would be worth cultivating on purpose in the future. Lammers made this discovery in the year 1830, since then the popularity of endive has astronomically grown, especially in Europe.

Cichorium endivia is a species made up of three main varieties, frisée endive, curly endive and escarole, or Belgian endive (Nolte, 2006). Though all varieties of endive are closely related to chicory, curly endive is often referred to as chicory although this is a misnomer. Frisée endive is typically served chopped, the thin, frizzy leaves adding a pleasurable texture and “bite” to salads due to the natural bitterness of the leaves. Leaves



of the frisée endive resemble the leaves of a dandelion (figure 1).

Frisée endive, note the resemblance to dandelion leaves. Photo credit arbico-organics.com
Curly endive usually grows in the shape of a heart, the dark green outer leaves prevent light from getting to the inner leaves, creating a blanching effect lightening the inner leaves in color and calming down the bitterness of these new leaves. According to Ryder,

growers will often purposefully maximize this blanching effect by loosely tying the outer leaves up over top of the younger inner leaves, thus improving the quality of the produce. The leaves of curly endive are slightly prickly, have wavy or curly edges and grow in loose bunches (figure 2).



Curly endive, photo credit depositphotos.com

Often curly endive will be served cooked, in soups or as a base for a warm green salad. Cooking curly endive softens the prickly leaves and tones down the natural bitterness, as this variety is the most bitter out of the group of three true endive varieties. Belgian endive is tightly bunched, broad leaved and typically more pale in coloration than curly or frisée endive (figure 3).



Belgian endive, note the broad leaves and paler coloration. Photo credit photodune.net

Belgian endive is most often eaten raw in salads with a vinegar based dressing to balance out the bitterness of the leaves. Belgian endive grows in tight bundles which grow

more vertically than spreading out like curly and frisée endive do. Nolte states that frisée endive is the least bitter variety, and that curly and Belgian endive have similar high levels of bitterness. Though the frisée variety is less bitter than the other listed two, this does not mean it is not bitter, this vegetable is prized for its natural bitter flavor.

It is likely that endive consumption in the United States will see a sharp upswing in the near future due to the fact that certain food and nutrition blogs have dubbed the leafy vegetable as the newest “superfood”, endive is dense with nutrients including fiber, folate, and vitamins A and K (Nolte, 2006). As with lettuce, endive purchased for consumption should be crisp, nicely green, lacking any brown spots or streaks and have no wilting in the leaves. Consumers should always inspect heads of endive, and any leafy green vegetable crop, before purchase to avoid taking home spoiled produce. Additionally endive should always be washed prior to preparation as to rinse any herbicides or pesticides which may have been applied during the growing process. Owing to its unique bitter, tangy flavor and pleasurable crispness, endive serves as a wonderful compliment to just about any mixed green salad. This hardy, leafy green vegetable can be produced on a small scale at home with relative ease and will reap great rewards if cared for properly.

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Magical Black Beans

By Casaundra Marie Jewell

Introduction

Beans have been a part of the human diet for over 7000 years (Flippone, 2018). *Phaseolus vulgaris*, is the scientific name for most beans, known as common beans. Black beans were started off in the central and southern Americas apart of dinner meals. The common bean serves essential nutrients for the human diet, black beans being a part of this group. They are now very popular in all dishes around the world. A vegetable is any part of the plant that can be consumed for human consumption (Dictionary). Black beans are considered a vegetable because they come from a pod on a plant.



Figure 19 (Nourish the roots, 2013)

Background Information

Black beans are considered a part of the legume family, Fabaceae, that are nitrogen fixators (Dalton, 2007). Nitrogen fixation occurs underground on the root nodules in all legumes. Black beans are not only good for human consumption, they are very beneficial for adding nitrogen to soil. Nitrogen is an essential element for plant growth.

Like most common beans, black beans are native to the Americas. When they were discovered it was considered a major grain for the diet thousands of years ago (Flippone, 2018).

A cultivar is an agricultural and/or horticultural organism undergoing changes to create variation from an original product. A few cultivars that I found in my research were 'Zorro' black beans and 'Zenith' black bean. These two cultivars were created for different reasons.

Michigan Agriculture Experiment Station created the cultivar 'Zorro'. It was bred in 2008 to be more disease resistant, midseason, drought tolerate, and upright. (Kelly, 2014). This specific cultivar was tested for 5 years before registering 'Zorro'.

Michigan State University also developed the cultivar 'Zenith' black bean in 2014. This experiment was tested from 2010-2013. It was created to increase yield and to be well adapted in other climates. 'Zenith' was tested in Michigan, Washington, and Ontario. Some other cultivars Michigan State University has created are, 'Shania', 'Eclipse', 'Loresto', 'T-39', 'B. Velvet', 'Jaguar', and 'Mean'.

Breeding and Selection

Like most agriculture and horticulture plants, they have been bred to increase yield, have greater disease resistance, flavor, and grow in more environments. These programs were designed in the united states to improve specific growing environments. There are many factors that influence breeding programs.

(Vandemark, Brick and Osorno) In different climate areas the temperatures vary throughout the year, days and nights.

Black bean is marketed in cans. They are located in the canned goods isle for two dollars or less (Jewell, 2018). It is very convenient considering the prep it takes to make black bean edible. It is rare for the average human to take dry beans and soak them for hours to then later enjoy in a meal. It is just simply inconvenient

to do so. If not done properly there may be toxins from the dry beans.



Figure 20 & 3 (Live Simply. Me, 2018)

Black beans are produced in Michigan, which produces 46% of the black bean harvested globally. The United States harvests 57.6% total (Kelly et al., 2014)). Michigan State University is one of the colleges that produces most research on black beans.

All common beans, *Phaseolus vulgaris*, from in pods that contain edible seeds. Beans are planted in early spring and are harvested in the late summer. When the pods are ready, they start to split open. That is an indication they are ready to be harvested. (Kelly, 2010) This can be done by hand or machinery depending on the amount needed to be harvested. After black beans are harvested you can start the process of soaking them for tacos, soup, hummus, and other fun foods for some protein. All beans contain a toxin, phytohemagglutinin, which can be harmful and uncomfortable if consumed in high amounts. If beans are undercooked, you take the risk of ingesting this compound. This compound is galactans, sugars that the body has a difficult digesting (Ware, 2018).

Production and Harvest

To grow black beans on a small scale or commercially, there are some factors to consider and get in order before starting a bean production. A farmer must have storage, a market for beans, and a buyer (Delate, 2013). Once that is all in place a farmer will start the production of growing black beans. Black bean yields are 20-30 bushels per acre and if the market is right they can go upwards of \$20 per bushel (Delate, 2013). Black beans are planted by mid-June in most states. After planting the plot is managed by weeding and pest management to ensure a good stand of the black bean crop.

Depending of the size of operations black beans are either harvested mechanically or by hand. Harvesting time is determined by the moisture in the black bean, should be at 18%, this varies with every legume (Delate, 2013). Once the black beans are harvested they are put into storage or shipped off to a buyer. After the buyer receives the beans they are then marketed in either canned goods or in bags as dry beans.

Nutritional Facts

Black beans contain a surprisingly amount of benefits for overall health. They provide proteins, bone health, essential nutrients, minerals to prevent cancer, and adds flavor to many meals.

Black beans contain a large amount of protein and are low in fat. They contain necessary carbohydrates and antioxidants. Black beans are great to add to any dish for extra flavor or protein. Legumes are very important in the human diet and have been for many years. A study done by M.R. Bennink, discovered black beans can reduce colon cancer in rats. Imagine what can be done in the years and what we will discover with black beans. (Bennink, 2009) Selenium a mineral found in black beans helps with liver enzyme function which can assistant with breaking down compounds found in the body that are cancer-causing. This can help slow down growth rates due to cancer (Ware, 2018).

Black beans contain calcium, magnesium, zinc, manganese, and iron that contribute to bone health and strength. Majority of these elements are contained in the bones and adding more consumption into your diet with sufficiently improve bones and joints (Ware, 2018)

You can use black beans for tacos, chili, hummus, veggie burgers, and so much more! Below is a photo of a black bean burger and you can find the recipe on Lauren Cares Cooks blog for a quick vegan option during the summer.



Figure 21

Fun Facts

Even though black beans provide many benefits, they can be hard on the human digestive system. Preparing your beans right can be easier on your body.

You can get creative with black beans and make brownies out of them for a healthier alternative. Black beans contain antioxidants that can keep a young and beautiful look with consumption. Black beans are also known to help detoxify the human body.

Conclusion

Next time you head to the store, I hope this gives you more of an insight where beans come from and the process it takes to get black beans to a grocery store. Black beans are an important edible plant in the human diet that we can get much nutrition from to improve the overall health that black beans offer. Instead of buying a can, buy some dry beans and soak them yourself. This way you can flavor the beans how you wish and get creative.

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Jicama

By Stella Karuna Kent

Jicama, or *Pachyrhizus erosus*, is a vegetable crop that is commonly grown for its enlarged edible root. Jicama has a number of common names, such as yam bean, and Mexican turnip/potato; many people would be surprised to learn it is not related to either a yam, a turnip, nor a potato for which it closely resembles. The root is large and oval shaped, with a light brown exterior and crispy white interior. When seeing jicama's enlarged brown root in the store one would likely never imagine that Jicama is actually in the legume family, Fabaceae, and grows a very large above ground vining system. Since it is a legume, jicama has nitrogen fixation properties as well. This vine does not only produce beautiful, delicate blue-purple flowers, but also pea-like structures. The large deep green leaves of the vine are alternate and produce three sets of leaflets, and all the while this plant is deceptively concealing the large tuberous root structure growing below (Plants For A Future [Date Unknown]).



Figure 1: Jicama botanical image

(Plants For A Future [Date Unknown])

Jicama grows well in more tropical climates, and is native to Mexico and South America. Jicama has been cultivated in these areas for many centuries, and has become an edible staple in Central and South American food. Since it is native to areas that do not

experience harsh winter climates, jicama does not grow well when exposed to colder conditions or frosts, so it is most commonly still cultivated in these areas of origin. We ship in a large majority of our jicama in the United States from Mexico, but it can be grown in much warmer areas of the U.S. such as Florida, Hawaii, and Puerto Rico (Information, Recipes and Facts [Date Unknown]).

There are two different cultivar of *Pachyrhizus erosus*, 'Jicama de Agua', and 'Jicama de Leche'. The two names of the cultivar indicate their characteristics. The 'Jicama de Agua' is the cultivar most commonly sold in grocery stores, it develops into a much more smooth and rounded tuber and produces a much more water-like consistency, whereas the 'Jicama de Leche' grows a more slightly rougher, more oblong root and has a much more milk-like consistency (Cultivo de Jicama [Date Unknown]).



Figure 2: 'Jicama de leche' (left) and 'Jicama de agua' (right)

(Cultivo de Jicama [Date Unknown])

It is challenging to explain the flavor of jicama, but when eaten raw it most closely resembles a slightly savory and somewhat starchy apple in flavor and texture. Jicama is most commonly consumed raw, but can also be cooked and used as a substitute for water chestnuts because it remains crisp even after cooking. To eat a jicama raw one carefully

cuts it in half and peels away the thickened outer peel with a small knife, then chops it up into small pieces (Mercado-Silva et al [Date Unknown]), I like to add some lime to mine. Although Jicama is a perennial, meaning that it has the ability to grow for an elongated number of seasons, in a production setting it is common to treat it like an annual, pulling up the root structure before it is able to reach seed producing maturity. Jicama is commonly treated as an annual because it has the best food producing quality at around 5-6 months of growth. This is before the edible root of the plant matures and becomes fibrous. If treated like an annual, the jicama is harvested at a size of 4-5 pounds per tuber (Johnson - 2012). In attempt to try and accelerate the growing process of the jicama tubers, it is common practice to clip the flowers and pea-like structures that grow on the above ground section of the plant as soon as they begin to grow. This is done to try and improve the plant's vigor in producing the tubers, sending more of the energy and nutrients of the plant into growing the tubers and not producing seed. If treated like a perennial, the jicama plant has the ability to grow very large vine systems, that can grow up to 20 feet in height and width. In a perennial system, the root of the jicama has the ability to weigh up to nearly 50 lbs and reach a length of nearly 6 feet underground, that is an astounding sized tuber! (Plants For A Future [Date Unknown]). Once the tubers grow this large they become much less appealing and more unpleasant to deal with, which is why it is rare to find a perennially grown jicama crop. Jicama is most commonly propagated by seed which can be done a very traditional way, or sometimes being planted into flats before being transplanted out into the field. A method for preparing the seeds for sowing is to treat them with a warm stratification, this is done by soaking the seeds for 12 hours in a warm water bath before sowing into the soil (Plants For A Future [Date Unknown]). The jicama seedling usually germinates within a

period of 7-10 days, and since this plant is a dicot, it produces a very small duo of cotyledons before beginning to produce its true leaves. Once the seedlings have around 3-4 true leaves they can be carefully transplanted into the field. The most important thing to keep in mind when planting jicama in the field is to create an adequate amount of space between seedlings so that the growing roots of each plant will not bump into each other. This means that the seedlings should be spaced at least 5-10 inches apart (Cultivo de Jicama [Date Unknown]). Once the jicama are ready for harvest they can be harvested by hand or by careful machinery.

There are some interesting facts about the jicama plant. One very important fact to always remember is that all parts of the jicama plant except the root are poisonous and should not be consumed! The only other part of the plant that can be consumed are the young seedpods, but they must be thoroughly cooked before consumption to destroy the poisonous compound present within the plant. This poisonous compound within the rest of the plant is called rotenone. Something interesting about rotenone is that it is an active ingredient in an insecticide called 'derris' and so the plant may have natural insecticide properties (Johnson - 2012).

Some other interesting facts are that jicama roots are comprised of about eighty-five percent water. Because of their resemblance to potatoes, jicama are commonly thought to be sources of large quantities of starch, but jicama has a number of nutritious properties. Jicama contains large quantities of vitamin C. According to a USDA nutritional study, jicama contains 22.4 mg of vitamin C per cup, which equates to around thirty to forty percent of the recommended daily value (USDA - 2018). Jicama also contains on average 5.9 grams of dietary fiber and 180 mg of potassium per cup (USDA - 2018).

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Asparagus

Jenae Kindsvater

Introduction:

Asparagus officinalis is a hardy perennial vegetable harvested in early spring. The word asparagus originates from the Greek word asparagos, meaning shoot or sprout (United States Department of Agriculture, 2018). The asparagus plant is botanically classified as a vegetable because it produces edible stems. Asparagus can be grown in home gardens or commercially. Roughly 74 percent of U.S commercial production of asparagus is sold fresh, and the remainder is sold frozen or canned. Initially asparagus was a part of the lily family, but after taxonomic revisions the vegetable was assigned its own family, Asparagaceae. (Hayley Boriss, 2006). This fact sheet covers the history, medical benefits, planting techniques, harvesting techniques, forms of consumption, the common cultivars grown today, and the domestic and foreign production of asparagus.

History:



The asparagus plant is believed to be originally found growing wild in Europe, the Mediterranean region, and western Asia during the 1st Century. Before the plant was grown as a food crop, it was recognized for its variety of medicinal benefits. Early English settlers brought asparagus to the US to be commercially grown during

the 19th century (Dave Long, n.d.).

Medicinal Benefits:

Asparagus is a delicious low-calorie snack that is loaded with beneficial nutrients. The stems are high in fiber, folate, protein, iron, potassium and many micronutrients. The vegetable is packed full of valuable vitamins: A, C, and K. It also offers trace amounts of vitamins E and B6, thiamin and niacin (University of Illinois Extension, 2018). The antioxidants found in asparagus reduce the likelihood of getting cancer and they slow down the aging process. In addition, antioxidants help reduce the cognitive impairment and chronic inflammation. Asparagus promotes regularity in the digestive tract. This is due to the high levels of asparagine, which is an amino acid that helps the body remove excess salt and insoluble fiber (Cheryl Forberg, 2018).

Planting Techniques:



Although asparagus can be started by seed, it is much more common to start them from 1-2 year-old disease free crowns. When finding a location to start production, it is essential to locate a site with full sun, good drainage, and enough space that the tall asparagus stalks will not overshadow other crops. Asparagus grow in trenches that sit 6-8 inches deep and about 12 inches wide. Fertilizer and freshly amended soil can be added to the bottom of the furrows before planting to increase yield. A soil test can be done and sent into local private or public labs to determine the appropriate amounts of fertilizers and lime to incorporate into the soil. Asparagus is known to grow best in a pH between 6.5- 7.5. The crowns are spaced 12 to 18 inches apart in rows that sit 4 to 5 feet apart. Once the healthy plump crowns get placed with the roots spread out and stem sitting upright, soil is filled into the trench (Iowa State University, 2018).

Harvesting Techniques:

Harvest time is limited until the third to fourth year to allow root development and time for the plants to mature and reach full flavor. Once the plants are strong enough to be harvested, the stems can be cut or snapped off just beneath the soil line in early spring when they are around 8 inches tall. The freshly cut spears need to stay hydrated to prevent the fiber from hardening at the base of the stem (Anderson, n.d.). The spears that are not in good condition to be harvested during the season are left behind to develop into shrubby ferns that grow to be 5-6 feet in diameter. Keeping the ferns until they die on their own, allows the plants to continue to photosynthesize, providing starch that can be stored in the crown until the following season. When the ferns have senesced remove them in late fall. Weeds create competition for the asparagus crop. A common management practice includes placing a layer of mulch over the soil to suppress weed growth and preserve soil moisture (Harrington, 2018).

Consumption:

Once the spears are harvested they begin to lose flavor and moisture quickly, so it is best to eat them as soon as possible. Asparagus can be consumed raw, steamed, grilled, boiled, or roasted however, the nutrients are most available with minimal processing (University of Illinois Extension, 2018). Asparagus is one of my favorite nutritious vegetables, I typically enjoy eating it fresh in a salad or lightly sautéed. I recommend using a drizzle of wine, oil, or balsamic vinegar to keep the moisture. To add flavor, add a pinch of salt, fresh garlic, lemon or even a sprinkle of parmesan.

Cultivars:

The 'Mary Washington' and 'Martha Washington' used to be the favored cultivars for U.S commercial production, but over time these cultivars were replaced by more productive and disease resistant cultivars. Today, the dioecious and all male cultivars dominate production (Swiader and Ware, Producing Vegetable Crops). The male plants are typically more popular because they generate seeds, giving the plants the ability to focus their energy on root development and spear growth (Swiader and Ware, Producing Vegetable Crops). A few examples of male varieties grown today for their vigorous growth and disease resistance include: 'Jersey Giant,' 'Knight', Jersey Prince,' and 'Jersey King.'

Production:

Asparagus production in the U.S has declined over the past 20 years due to increasing imports from Central and South America. Michigan, Washington, and California are the main states that contribute to U.S commercial production of asparagus. California is the leading producer because it, contributes 50% to total production. In 2017, approximately 23,300 acres of asparagus were harvested in the U.S, with an average yield of 2,880 pounds per acre. In 2017, the U.S. commercial value of asparagus was approximately \$73.1 million (Iowa State University, 2018). Worldwide, China cultivates more Asparagus than any other country, accounting for 88 percent of world production. Peru is the second largest producer making up 3 percent of the world production followed by the United States being the third largest producer accounting for 1.6 percent (Hayley Boriss, 2006).

Fun facts:

Asparagus contains the organosulfur compound asparagusic acid that flushes through the body and immediately becomes volatilized at room temperature, causing urine to smell especially strong.

Some people cannot smell the odor due to a specific genetic mutation that makes the smell of the sulfuric compounds undetectable (Dave Long, n.d.).



Asparagus grows in green and purple varieties. White asparagus are green varieties that are blanched. Blanching is a process in which the stems are covered by soil to prevent exposure to sunlight, resulting in a lack of chlorophyll formation (Swiader and Ware, Producing Vegetable Crops).

Asparagus are one of the few vegetable crops that is classified as a monocot, similarly to yams, sweet corn, onions, and other related crops. (Swiader and Ware, Producing Vegetable Crops) .

Conclusion:

Asparagus is more readily available than it has been previously, due to year-round production. The initial production costs are high, but once the crop has been established it can be harvested year after year with minimal maintenance requirements. It is important to acknowledge the relatively high labor cost. The average retail price for fresh asparagus is \$3.08 per pound (Stewart & Hyman, 2018). I chose to write about asparagus because I am fascinated by its unique characteristics such as its classification as a true perennial and its ability to produce an edible stem (Swiader and Ware, Producing Vegetable Crops). These green stems are a great food to incorporate into a regular diet plan. They are low in calories and carbohydrates but provide beneficial vitamins and nutrients, that can lead to a healthier life.

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Figure 2: (unknown). *Focus on Growing Asparagus*. Otaki, 2015 <http://otakimail.co.nz/focus-growing-asparagus/>

Figure 3: Susan, *Tri Color Asparagus*. Simple Healthy Kitchen, 2016 <https://www.simplehealthykitchen.com/tri-color-asparagus-risotto/>

Okra Fact Sheet

Paul Lorenzo

Okra, a multi-use specialty crop, is a warm-season fruit also named *Abelmoschus esculentus* in the family Malvaceae. This species is closely related to hibiscus, a common ornamental plant, and forms similar-looking blossoms (Warrier et al., 2011). Okra may also be called “Lady’s Finger” or “gumbo,” although gumbo typically refers to a soup or dish containing okra (Boswell, 2000). Although still growing in popularity in the U.S., okra has been consumed in various parts of the world for thousands of years, making it an economically and horticulturally important crop.

Okra is grown as an annual plant and grows upright to a height of 0.5-4 meters (Takele et al., 2012). Its leaves are heart-shaped and lobed with long petioles that attach to the stem. Leaves are usually hairy, and may grow to 30 cm in length. According to the National Research Council in 2006,



Figure 1: A flowering and fruiting okra plant (Bender, 2018).

okra flowers form individually and are typically “yellow with a dark red or purple base” (p. 300). Flowers, and subsequently pods, develop on the axials of the plant. Okra pods, the fruit, are generally ribbed or round and may be yellow, green, or red. Pods can grow up to 10-25 cm long, although they are picked young for maximum flavor. Each pod contains edible seeds about the size of peppercorns (National Research Council, 2006). Although the part of the plant which is eaten is the fruit, okra is included in olericulture for reasons similar to those within the family Solanaceae: these plants are non-woody and can be planted and harvested in rows like vegetables. A photograph of a fruiting okra plant is shown in Figure 1.

Okra originated from the area of current-day Sudan and Ethiopia (Boswell, 2000). Gradually, the plant was taken to northern Africa and spread eastward. Okra has been grown in

India since around the time of Christ. African slave traders brought okra to the west, which enabled the French to introduce it to the Louisiana area around 1700. The plant is referenced in numerous American gardening texts from the 1800s. Today, okra landraces can be found growing in Ethiopia (Bost, 2010).

Okra is suited to well-draining soils containing organic matter. Excessive soil moisture may negatively affect sensitive cultivars, so slightly sandy-textured soils may be preferred. When planting, 20,000-30,000 plants are sown per hectare. Okra is typically direct-seeded and can be planted in the spring once soil temperatures reach above 60° F which stimulates germination. Since okra seeds have a thick seed coat, seeds are soaked overnight to improve germination (National Research Council, 2006). If using transplants, okra can be transplanted after the spring season's last average frost which is around mid-May in Colorado. Covering the soil with black plastic mulch helps warm the soil in the spring and exclude weeds throughout the growing season (Colorado State University Extension, 2017). Night temperatures should not fall below 55° F for adequate plant growth. Okra grows best in temperatures between 68-86° F for both vegetative and reproductive development (National Research Council, 2006). A soil pH between 5.8-6.5 improves nutrient availability and supports optimal okra plant growth (Colditz et al., 2014).

Crop rotation is important to consider when growing okra. The plant is susceptible to nematode damage, so planting okra following a season of grasses or small grains may help prevent massive nematode populations. Comparatively, vine crops like squash and sweet potatoes may increase nematode population numbers, so okra should not follow these crops in a rotation (Colditz et al., 2014).

In general, okra does not attract many pests. However, there have been a few pests associated with okra production in the southern United States. Aphids, corn earworm, and stinkbugs may be potential pests. Okra may also be susceptible to *Verticillium* and *Fusarium* wilts,

so scouting for these fungal diseases and insect pests is important during okra production (National Research Council, 2006). Throughout pod harvest, regularly scouting while harvesting every couple days is likely the most efficient way to monitor and maintain plant health.

The plant typically begins flowering around two months after planting and is self-pollinating. Some out-crossing may occur if there are large bee populations nearby, but this is not needed for fruit to set. Once pods begin to develop, they should be harvested multiple times a week before the pods' skins become tough.

Harvest is typically 4-6 days after flowering. Figure 2 shows the stages of pod development each day the pod is left on the plant. Harvesting on day 7 or 8 results in a longer, heavier pod. However, its tough skin and declining flavor makes it undesirable at market. Harvesters may use

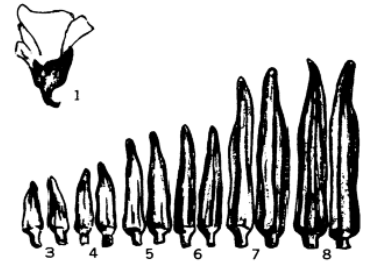


Figure 2: Stages of pod development by day (Colditz et al., 2014).

soft cotton gloves to prevent pod damage when handling the fruit (National Research Council, 2006).



Figure 3: Okra pods and seeds (LaFollette, 2010).

After harvest, okra pods are washed in a large tank of water for cleaning. The pods need to be cooled quickly because they have high respiration rates. After removing excess moisture, pods are stored at 45° F with a relative humidity of 90-95% to prevent pods from shriveling and appearing wilted. Below temperatures of 45°, okra pods may become

discolored and disfigured which affects their salability. Pods have a shelf-life of 7-10 days, so okra should be sold as soon as possible once harvested (National Research Council, 2006). A close-up of okra pods and seeds are shown in Figure 3.

Although many plant breeders do not typically choose to work with okra because it is a minor crop, new cultivars are gradually introduced to the market. Cultivars differ in their pod

shape, days to maturity, end-use, yield, and other qualitative differences. An okra plant's number of days to maturity may range from 50-60 days depending on cultivar. Certain cultivars tend to be better suited to specific markets. Buyers that market fresh okra generally prefer to buy star-shaped pods. Common cultivars with this pod shape include: 'Clemson Spineless #80,' 'Dwarf Green Long Pod,' and 'Hastings Improved Perkins.' 'Clemson Spineless #80' is also known to be a high-yielding cultivar. When okra is marketed in soups, buyers prefer round-shaped pods. These commercial cultivars are often 'Emerald,' which is also good for canning, or 'Louisiana Green Velvet.' Frozen food packaging companies have historically accepted both star and round-shaped pods (Colditz et al., 2014).

In the U.S., Texas, Georgia, California, and Florida are the main producers of okra. Peak okra production months are from June-August, although California producers ship their product from June-October. Mexico exports okra throughout the year, although the U.S. imports most of its okra from June-September. Since okra is a minor crop, its sale figures are often combined with other minor vegetable crops when reported. However, some okra-specific market reports indicate that California's okra production has fallen each year from 2005 to 2007 with 504 acres of okra planted and 223 acres, respectively. Productivity also fell between these years from 5.0 tons of okra pods/acre to 3.4 tons/acre in 2007. This resulted in a loss of gross revenue totaling approximately \$1,600 per acre (Aguilar et al., 2011).

Internationally, the U.S. produces less than 1% of the world's okra. Countries with climates better suited to okra production are much more competitive in this market. India is the world's leading okra producer. In 2011, the country produced 73.25% of all the okra produced that year. This totaled around 5.8 million tons of okra grown on 498,000 hectares, or approximately 1,230,600 acres. Overall, global okra production reported for 2011 reached almost 7.9 million tons (APEDA, 2012).

Okra's texture may be off-putting to some because it has a gooey, mucilaginous quality which makes it an effective thickener for soups and stews. This quality is enjoyed by many in the southern United States, as it is used as a thickener for popular dishes such as Louisiana Creole gumbo. Pickled okra is another popular use for the fruit. Others may slice and sauté the pods before eating. To preserve okra, the pods can be blanched in boiling water for 3-4 minutes and then cooled quickly by placing them in cold water. These can then be frozen for storage. Another preservation method is drying out the pods in a dehydrator for 8-10 hours for increased storage expectancy (Bost, 2010).

In some areas, okra seeds are sometimes preferred over the whole pods. When ripe, okra seeds contain high quality edible oil which is comparable to olive oil that may be used for cooking. These seeds are a good source of protein and oil—around 40% of okra seed kernels is oil (National Research Council, 2006). The oil has a short shelf life, but has a pleasant odor and consists of approximately 70% “unsaturated fatty acids—especially linoleic and oleic” (p. 293). The seeds may also be roasted and ground for use as a coffee substitute. The resulting decaffeinated “coffee” has a pleasant aroma. This brew was once common in Central American countries, Africa, and Malaysia (National Research Council, 2006).

Okra leaves are also edible. They are most commonly eaten in west Africa and southeast Asia. Tender okra leaves may be a regular part of the diet and are cooked similar to spinach. They can be sautéed or used in soups and stews. In west Africa, tender shoots and flower buds are also often added into soups and stews, as well. Leaves may also be sun-dried and either crushed or ground into powder to season dishes in the future. The leaves taste slightly acidic. Cooking the leaves before consumption helps reduce the acidic taste. Okra leaves and immature pods have also been used in the East in poultices to relieve pain and/or reduce inflammation (National Research Council, 2006).

While still considered a minor crop, okra has been utilized in many different ways for hundreds of years in various parts of the world. In some cultures, okra is grown primarily for fruit production and consumption. Other cultures may grow the plant for its seeds for use in oil production. There are some cultures, such as those in west Africa and southeast Asia, that have found uses for its leaves, shoots, and flower buds, as well. This versatile plant may also have properties that reduce inflammation and relieve pain. In the United States, okra is most popular in the south where it has become a staple in some dishes, such as the Louisiana Creole gumbo. There are many applications for this plant that have not yet been explored in the United States, likely because its popularity is concentrated to certain areas. As more consumers experiment with and learn more about okra and its benefits, the market for okra within the U.S. will grow to accommodate increased demand. The crop has many uses, and there may be more in the future if potential applications and benefits of the plant are researched more thoroughly.

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Shallots

Lael H. Mathis

A Shallot is a horticulture vegetable used in the culinary world. The Latin or scientific name for a Shallot is *Allium cepa*, (Aggregatum Group). It is considered a vegetable because it is a crop grown for the vegetative portion of the plant, not the fruit nor the seeds, or flowers.

Though, it is in the Alliaceae, the same family as the beautiful purple Allium flowers you see in ornamental displays (Swiader & Ware, 2002).

Shallots are grown for their flavorful bulbs like the ones pictured on the Allium Cepa seed pack found in Figure 1. The definition of a bulb is “a

subterranean leaf-bud with fleshy scales or coats” (Swiader & Ware, 2002). Bulbs function as storage organs or food reserves by storing proteins carbohydrates and sugars for the plant to use during respiration and other essential growth mechanisms. (Britannica, 2018). When the plant

has gained enough of energy it can then send up

foliage to then differentiate into reproductive tissue such as stamens and pistils. After

pollination, the ovary will then fruit/seed in order to spread its gene pool and grow more

shallots. When growing shallots if the plant gets to this flowering stage or bolts, the vegetable

would lose value because the bulbs don't store as well when they are mature. (Marshalls, 2018).

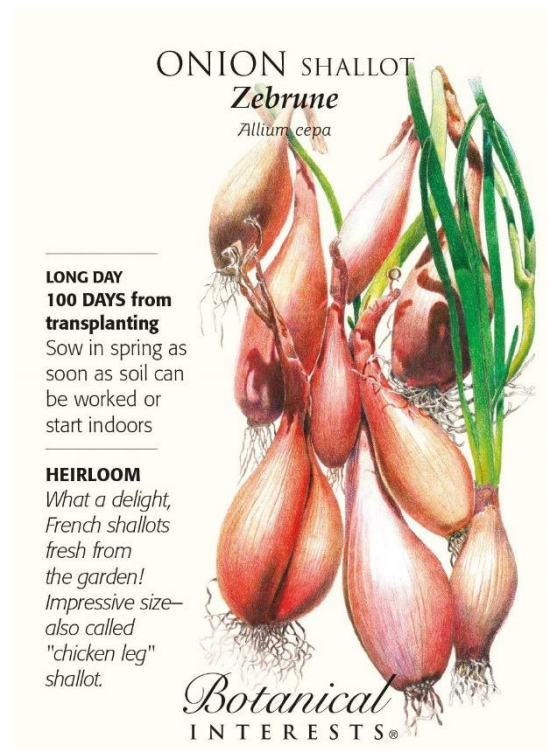


Figure 1 – Shallot Seed Pack

Before Shallots were named *Allium cepa*, they were originally named *Allium ascalonicum*. The crop was introduced to the Europeans during the 12th century. “Crusaders brought them home as ‘valuable treasures’ from the ancient Palestinian city of Ascalon” (Nolte, 2018). This is why they previously had the shallots specific epithet *as ascalonicum*. Today Shallots are formally known as *Allium cepa*. (Swiader & Ware, 2002). Shallots are still considered valuable treasures to many as they are pricey when it comes to buying them at grocery stores and markets. According to, (Tridge, 2018), shallots are priced at \$1.8 per kilogram. Shallots have a small footprint in the commercial market in the U.S but are widely produced in Mexico, Republic of Korea, Japan and China. Mexico is the top producer at 1’200 tons per year, (Tridge, 2018). Following the Republic of Korea at 606,000 tons per year. In third, Japan at 532,000 tons per year and lastly China at 351,000 tons per year, (Tridge, 2018). China is ranked one of the highest onion consumers followed by India and the United States, (Helgilibrary, 2013). As well as China ranking in top consumption they also rank as a top producer of shallots. Looking at this information and seeing that China ranks high both in production and consumption one could asses they have a strong local market for shallots which could reap economic and environmental benefits for the country. Out of the many cultivars of Shallots that are produced, exported and consumed the cultivar that is prized in the culinary world that chefs call the “only true shallot” is the “French Grey Shallot” or *A. oschanini*. Grey shallots are used to flavor fine cuisine like an onion would but not used as a the main “protein” of the dish. Not only do shallots give off a sweet oniony flavor but also have many great health benefits, (Organic 2018).

Replacing Shallots with onions in a recipe can have many benefits. Shallots have higher iron, copper and potassium mineral contents than onions. Having a higher dose of these minerals

helps with boosting circulation in the body as well as cell regrowth, and metabolism, (Organic, 2018). Another health benefit that shallots reap comes from a compound formed when shallots are sliced called allicin which helps with lowering cholesterol. One last awesome health benefit is that Shallots can soothe nerves! Pyridoxine is a vitamin found in shallots that releases Gamma-Aminobutyric acid in the brain which is important for maintaining low levels of stress, (Organic, 2018). Adding Shallots to your diet can boost your health in many ways as well as add flavor to many dishes.

When growing any crop the first step is to find the best way to propagate the crop to produce a quality crop and a large yield as well. *Allium cepa* (Aggregatum Group) is



is **Figure 2 – Planted Shallot Bulbs**

growing in order to plant them during the best time of year for each different type. For example, the three types of Shallots that are most commonly grown are Gray Shallots or Grissles, Red Shallots and Gold Shallots.

Grey Shallots have a shorter dormancy period and break dormancy in the fall so they are usually planted mid-September, (Albert, 2018). Gold and Red Shallots are planted during the opposite season of when Grey Shallots are planted. These two cultivars are started in the spring

propagated vegetatively. If propagated by seed the production process would take longer and wouldn't be productive due to additional days of production. Shallots are propagated by bulb division. Another thing to consider which cultivar of Shallots you are

instead. When preparing beds, rows, or fields, it is important to consider adding nitrogen as well as tilling to prepare the soil for the season. For every acre adding 50 lbs. of N fertilizer will be necessary. Fish emulsion is a widely used in the production of shallots that are grown under certified organic management as way to increase nitrogen levels in the soil. When it's time to plant bulbs, spacing is important in determining quality and size of this crop. Bulbs should be planted 3 or 4 per foot in rows 18" to 24" apart and 1" deep, (Hemphill, 2010). You can view an example of this spacing in Figure 2. After planting irrigation is the next step in production. Irrigation should be frequent keeping the soil moist. Since Shallots are "shallow rooted" they will grow better with frequent irrigation, (Hemphill, 2010). Late in the season when the bulbs are getting close to a marketable size growers usually reduce the amount of irrigation to prevent the spread of disease. (Hemphill 2010). If planted in one acre a grower can yield up to 9-12 tons! When it's time to harvest 12 tons of Shallots make sure the bulbs are at least 1-2 inches and have papery outer skin. Another sign to look for when seeing if shallots are ready for harvest is looking for bulbs that are protruding out of the soil similar to how a ready to harvest radish would. As well as protruding bulbs, a good sign of harvestable shallots are when the foliage of the bulb starts to wither, (Patterson, 2018). If 12 tons of shallots were not produced and you are able to harvest by hand that will work fine. In production, mechanical harvesters are a good investment in correlation to time or more commonly labor or field laborers often harvest the crops. Once harvested the Shallots are "topped". which means that the green tops or foliage is cut off the bulb as well as the roots. The bulbs must be stored in dark, dry, well ventilated areas after being cured (preserved/dried), (Albert 2018). The time period Shallots take to mature and become ready for harvest is about 60 to 120 days. (Albert 2018).

From the ancient city of Ascalon to France and China, Shallots have been widely used as a horticulture crop for century's. Shallots are mainly used to flavor other vegetables and proteins. These vegetative bulbs have many health benefits when incorporated into your diet such as boosting circulation, increasing metabolism, or lowering cholesterol. As a grower, they can be very profitable in a market that values this crop since they can be produced in mass quantity as quickly as only 60 days of production time. Once shallots are ready to harvest they don't go through much processing besides curing unlike agricultural crops. This simplicity after harvest is the beauty of a horticulture crop.

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The U.S. Victory Garden

Cole McCullough



Victory garden history

When the United States joined WWI in 1917 most of Europe was in a severe food crisis as a result of destroyed crop land, lack of farm labor, supplies being cut off, and increase military demand (Lawson, 2014). U.S. citizens were called upon to create 'war gardens' anywhere from their backyards to extra farm land to grown vegetables and fruits to help fill the ever increasing civilian and military food consumption overseas. In 1941 the U.S. entered WWII, facing similar food shortage problems seen in WWI a National Defense Gardening Conference was held in Washington DC on December 19, 1941 to discuss the potential benefits of another nationwide 'war garden' like effort (Lawson, 2014). As a result of this, the Victory Garden Program was born. This program, according the USDA, was designed to "[focus] on maintaining the strength and physical health of the U.S. domestic population" rather than directly supporting the military and Allies as seen in WW1. Benefits of this nationwide program included increased domestic food supply, reduced pressure on domestic transportation, and placing less demand on resources needed for war efforts, such as; tin, labor, power, and machinery used by commercial food industries (Lawson, 2014). By the end of 1944, it was reported that between 18 and 20 million families had gardens that collectively provided 40% of the total vegetable supply in the U.S. (Lawson, 2014)

Victory garden success

Along with the support of multiple government and private organizations providing information about developing and maintaining victory gardens, people during WWII felt that it was their duty to the country to plant a garden. Participating in gardening was a way for people to feel like they were doing their part in defending the country. The new attitude seen in the Victory Garden

Program helped develop a self-interest in taking care of oneself, which in turn, reflected greatly on the entire Nation (Miller,2003). People enjoyed gardening and the opportunity to see their hard work pay off. Many people reported how they felt closer to nature when gardening and how it allowed for a brief escape from a chaotic war (Miller, 2003).

Common vegetables grown in 1944

Some of the most popular produce grown included beans, beets, cabbage, carrots, kale, kohlrabi, lettuce, peas, tomatoes, turnips, squash and swiss chard (Schumm, 2014).

Help for the Gardener

Over the course of the program the USDA developed a series of ‘Victory Garden Aids’ to help provide information about various methods of creating and maintaining victory gardens. Today similar help is offered in the form of extension based programs and classes.

Examples:

Leadership

Victory Garden Leader's Handbook (1943).

Author - Boswell, Victor Rickman. U.S. Department of Agriculture.

This handbook was published with intent on helping individuals, groups, and organizations who were seen as ‘leaders’ in the gardening community. The handbook offered suggestions on how to give guidance to those in suburban back yards, community gardens, and school gardens. It also explained how you can look for inefficiencies in the garden and give advice about fertilizers, land use, labor, and seed use.

Insects and Pests

Victory Garden Insect Guide (1944).

Author - U.S. Department of Agriculture.

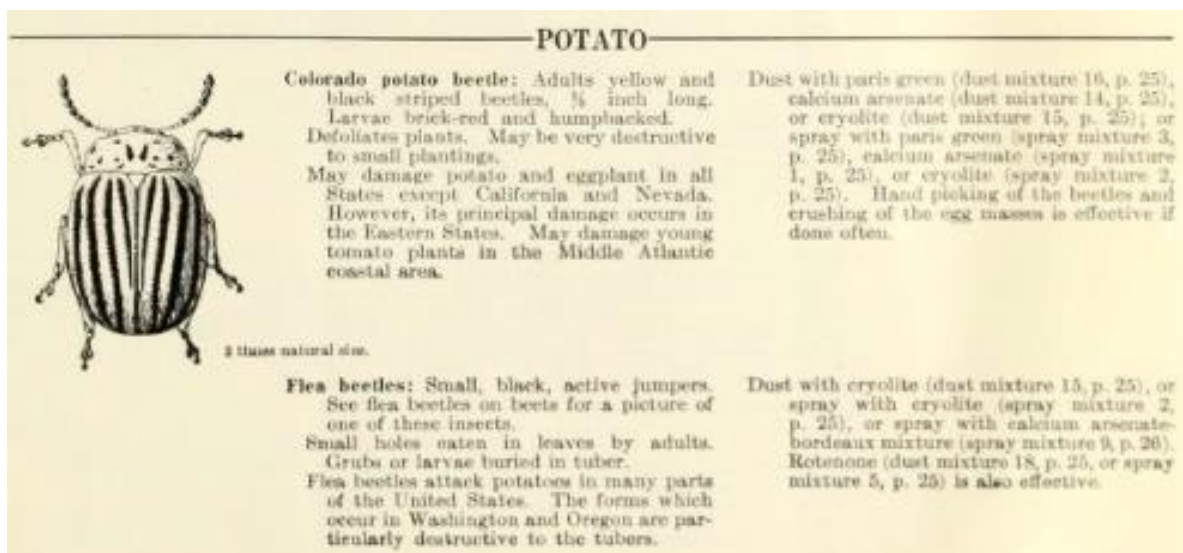
A Victory Gardener's Handbook on Insects and Diseases (1944).

Authors - White, William Henry and Doolittle, Sears Polydore. U.S. Department of Agriculture

Both publications aim to help the gardener identify and manage common garden insects and diseases. Garden pests were advertised as “enemies” that needed to be stopped. They included extensive charts with specific information about each commonly found insect and disease, as well as, the vegetables commonly associated with them and the best-known management practices during that time. Both publications made an effort to describe simplified directions for the

preparation and use of pesticides.

Figure 1.



Victory Gardeners Can Prevent Ear-Worms From Entering Their Corn (1943).

Author - U.S. Department of Agriculture

This publication was developed to specifically address persistent problems with ear-worms. It included information on life stages of the insect along with the best-known treatment; white

mineral oil or refined mineral oil containing 0.2% pyrethrin applied directly to the inside of each ear's tip using an eye dropper.

Post-Harvest

Drying Foods for Victory Meals (1942).

Author - Bureau of Human Nutrition and Home Economics. U.S. Department of Agriculture.

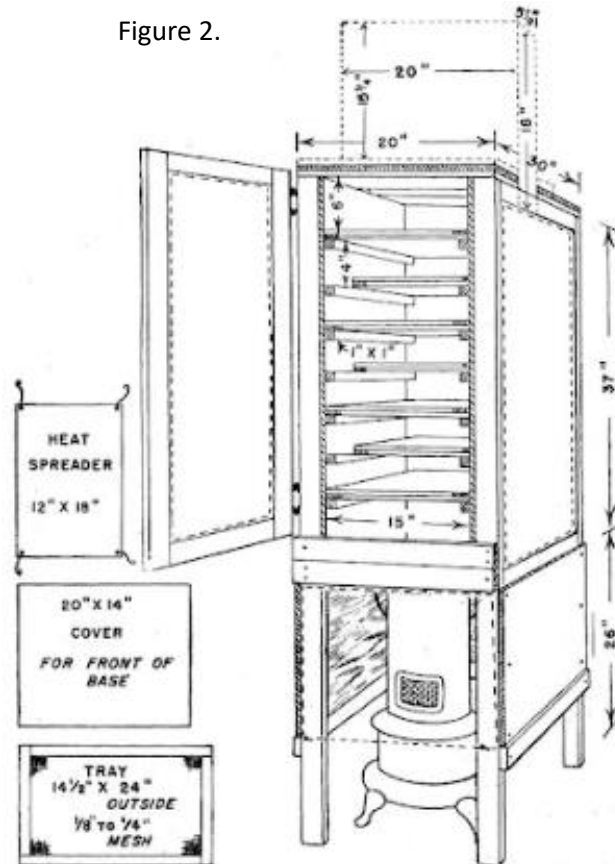
Farmers' Bulletin: Number 1918. T

The USDA provided information on the preservation of harvested food from gardens. Due to the limited space and reliability of refrigeration during WWII, drying fruits and vegetables was a common practice. This article provided information about properly preparing, drying, and storing the most common fruits and vegetables grown in victory gardens. Also included were different methods of

drying, how to properly test dryness, and even diagrams on how to build a simple drying system at home. The publication mentions an interesting method for fruit preparation before drying

known as “sulphuring.” For this process, fruits are placed on racks in a closed “chamber” with sulfur burning underneath for 5-7 minutes. The article states that if done properly, burning 1 teaspoon of sulfur for every pound of produce is completely harmless and would protect certain vitamins during drying, as well as, preserve natural coloring and flavor.

Figure 2.



Home Canning of Fruits and Vegetables:

Seven Points for Success (1944).

Author - Bureau of Human Nutrition and Home Economics. U.S. Department of Agriculture. AWI: Number 93.

Canning, known commonly today as jarring, was the main way to store food harvested from the garden. Canning allowed for long term storage with minimal impact on resources needed for the war. This article gave gardeners everything they needed to know about the canning process. There were charts with specified canning information about different fruits and vegetables. Diagramed step-by step instructions of canning from start to finish. The article included instructions on how to make a pressure canner at home, along with, diagrams of different jars and their seals. Similar articles published around the same time provided information about maintaining a pressure canner and community canning.

The end of victory gardens

As WWII was coming to an end, the need for the Victory Garden Program started to decrease. The program had always been developed as a temporary solution to some of the large problems the U.S. and Allies were facing during the war. Soon government directed campaigns for the program fell along with their resources of organization capacity, technical assistance, and land access. With soldiers returning home, land that was donated to garden space was now being converted to either its previous use, housing, or other civic improvements (Lawson, 2014).

Connections to the past

Not all victory gardens were lost, a few gardens still exist today as historical landmarks. The Fenway Victory Garden was established in 1942 in the heart of Boston, MA. The garden consists of 500 plots maintained by both individual gardeners and community organization representing a diverse mix of ethnic groups, occupations, ages, and socioeconomic backgrounds (The Fenway Garden Society, 2018). The Rainbow Beach Victory Garden is the last victory garden left in Chicago, IL. The garden was started during WWI and later adopted the victory garden name during WWII. A “seed to table” approach to gardening, respect for the earth, and respect for the community are common values all members of the garden possess (Chicago Park District, 2018).

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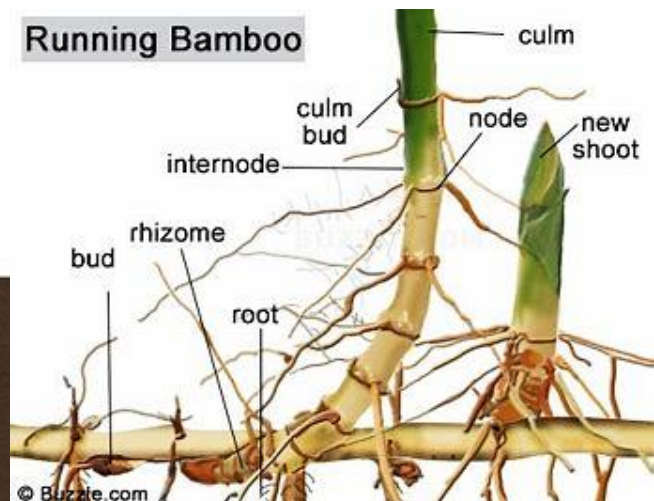
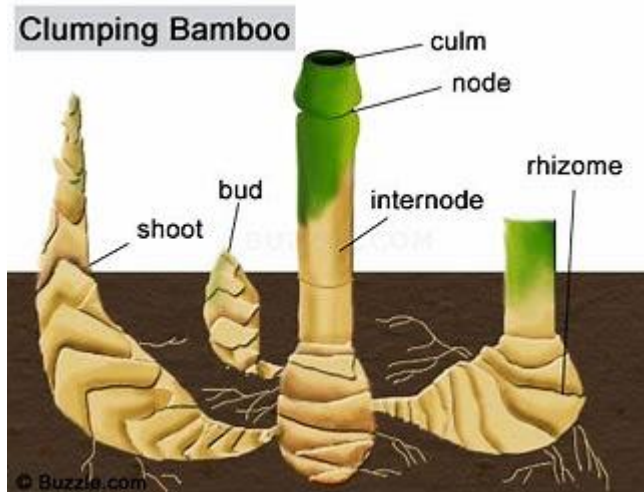


Bamboo Shoots

By Hailee Meiners

Bamboo shoots are a common ingredient in many oriental dishes. In recent years they have become popular across many cultures. Depending on the species it can be consumed raw, dried, boiled, canned, fermented, or for medicinal purposes. There are 75 genera and 1250 species of bamboo but only a few are considered and utilized as edible varieties, roughly 110 species. While the bamboo itself is a woody grass species and would not be considered a vegetable, the shoots are edible stems which are prepared and handled similar to other vegetables (Diver). The shoots are usually associated with a tender and mildly sweet flavor which can accompany almost any dish. There are many factors to consider when growing, harvesting, preparing, or eating bamboo shoots.

The shoots are the new growth produced by the parent bamboo plant as part of a jointed stem which forms underground; this is a method of clonal propagation and is common in grass species. Because it is actively dividing and developing tissue it is often tender, especially compared to the mature woody structure of the parent. It is best if these shoots are not allowed to grow above the surface of the soil as they begin to develop a denser, woody structure and lose the desired taste. There are two main categories of bamboo: sympodial (which grow in clumps and have short rhizomes) and monopodial (which are running varieties and have long rhizomes) (Cyanogenic glycosides in cassava and bamboo shoots 2004).



Some species contain cyanogenic glycosides specifically taxiphyllin (p-hydroxylated mandelonitrile tiglochinin) which has a bitter taste. Taxiphyllin can be potentially toxic as it is activated by β -glycosidase if the plant cells are disrupted. It breaks down into a sugar and cyanohydrin which breaks further into hydrocyanic acid (Choudhury et al. 2010). Hydrocyanic acid is an aqueous solution of hydrogen cyanide (HCN) which is toxic. Hydrogen cyanide is a non-competitive inhibitor of cytochrome c oxidase and ultimately stops oxidative phosphorylation (which is responsible for the majority of the production of ATP and vital for cell function) in living tissue and in large amounts causes cardiac arrest in humans (and other animals). Humans can process and

eliminate small amounts of hydrogen cyanide although other complications can potentially occur for children, elderly, pregnant women or women attempting to conceive. Acute toxicity (usually chronic exposure) of hydrogen cyanide has been linked with thyroid malfunction as well as neural effects. Konzo is a motor neuron disease associated with cyanogenic compound consumption or exposure to sub-lethal doses of cyanide. These conditions can be avoided by consuming a well-balanced diet especially containing sulphur amino acids (methionine and cysteine, also taurine) which act as sulphur donors to produce thiosulphate which is utilized by the enzyme rhodanese to convert cyanide to thiocyanate and is excreted through the urinary tract and is the major pathway for eliminating cyanide (see Figure 1)

(Cyanogenic glycosides in cassava and bamboo shoots

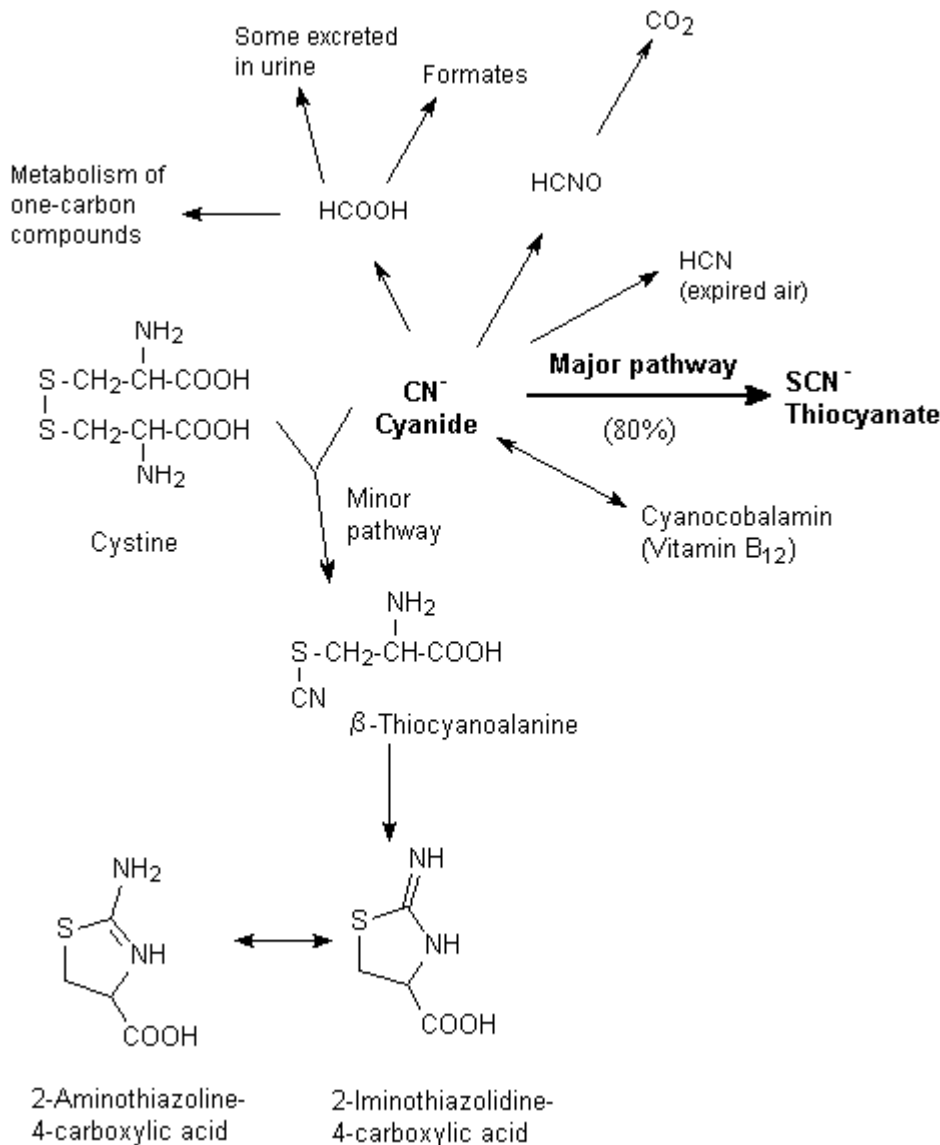


Figure 22: Biological pathways for converting and eliminating cyanide

2004). Minor reactions which help to eliminate cyanide include cystine (oxidized form of cysteine) and Vitamin B_{12} 's formation of complexes with cyanide (cysteine: 2-imino-thiazolidine-4-carboxylic acid; B_{12} : cyanocobalamin) as well as the formation of formic acid. All these compounds can be excreted safely. Another way of avoiding any toxic effects of the cyanogenic compounds is through the proper handling and processing of plant material and foods containing

cyanogens. Bamboo shoots can be detoxified by boiling or cooking for 2 hours; however, incomplete cooking and processing can result in higher levels of hydrogen cyanide (Choudhury et al. 2010). Required preparation and processing is highly dependent on the species of bamboo and the levels of cyanogenic glycosides present (see Figure 2).

Bamboo shoots are low in fat and cholesterol but have large amounts of potassium, carbohydrates (5.7%), and dietary fiber. They also contain vitamins, amino acids (3.9% protein), and antioxidants like flavones, phenols, and steroids (see Figure 2).

Table 1—Chemical compositions of commonly edible bamboo shoot species¹²

Nutrients	Bamboo species						
	<i>B. balcooa</i>	<i>B. polymorpha</i>	<i>M. bambusoides</i>	<i>D. strictus</i>	<i>D. hamiltonii</i>	<i>D. giganteus</i>	<i>B. pallida</i>
Water (%)	91.65	91.65	91.22	85.98	92.37	91.19	92.29
Protein (%)	2.74	2.10	3.29	1.98	2.60	2.59	2.31
Minerals (%)	0.99	0.91	0.98	1.14	1.01	0.89	1.12
Hydrocyanic acid (%)	0.071	0.032	0.056	0.13	0.070	0.044	0.106
Carbohydrates (%)	3.90	4.86	3.93	9.94	4.00	4.78	3.83

Table 2—Major nutrient composition of four important edible bamboo species⁶

Species	Food Energy (MJ/kg)	Moisture (% wb)	Protein (% db)	Fat (% db)	Carbohydrates (% db)
<i>B. balcooa</i>	15.64	84.0	3.87	0.60	5.23
<i>C. hookeriana</i>	15.96	79.0	3.56	0.62	5.94
<i>D. hamiltonii</i>	16.40	87.0	3.90	0.50	5.70
<i>M. baccifera</i>	15.80	75.5	3.62	0.57	6.12

Table 3—Hydrogen cyanine content of commonly edible bamboo shoot species (in mg/gm)

Region of the shoot	Bamboo species				
	<i>D. hamiltonii</i>	<i>B. pallida</i>	<i>B. tulda</i>	<i>B. balcooa</i>	<i>M. bambusoides</i>
Tip	2.42	0.27	0.17	2.15	1.81
Middle portion	0.86	0.17	0.83	1.38	0.68
Base	0.15	0.13	0.28	0.62	0.35

Figure 23: Choudhury et al. (2010)

Production of bamboo shoots can be an intensive agriculture and requires higher quality resources like soil, water, and access to fertilizers and amendments may be necessary as well. The first harvest occurs around 2.5 years after planting and the best quality shoots are harvested in the middle of the growing season (Kendra 2008). The genus *Phyllostachys* is generally cold hardy and produces quality shoots. There are also a few edible species in the genus *Fargesia* which is also known for its cold hardiness. Bamboo requires large amounts of water to produce a tender, sweet shoot. It also has very high nitrogen demands and depending on soil levels of nitrogen requires fertilizing 2-3 times per year and are generally applied in the spring and again in the summer (Growing and Maintaining Bamboo). Most species grow best in a moderately acidic and well-draining soil like a loam. The addition of organic matter can be beneficial to growing bamboo

although manure should be used cautiously especially in shoot production systems because it can expose the new shoots to pathogens as the shoots reach the surface.

Bamboo shoots are generally 20-30 cm long and close to a pound in weight (Satya et al. 2009). Large diameter species can be allowed to grow until the shoot is approximately 12 inches in length; however, smaller diameter species should be harvested before the shoot is 6 inches (Barth 2018). In order to harvest the shoot, the soil surrounding it must be removed or broken up to a depth of 15 cm and roughly 30 cm around the shoot. The shoot is then cut at the base or some species can be twisted and removed by hand. Once the shoot is removed, it is important to leave the site of the shoot exposed and unburied to prevent infection and reduce sap flow to the cutting (Kendra 2008). The area is left for 5 days depending on the conditions and until the risk for infection has been reduced. For management purposes and to maintain quality shoots and a healthy stand, shoots are harvested selectively, resulting in 50-60% of the shoots actually being harvested from a plantation.



After being harvested, bamboo shoots are prepared for processing and consumption. First, the developing leaves create a sheath around the shoot which must be peeled away (as it contains higher concentrations of cyanogenic glycosides) (Singh and Das 2011). The sheath is the dark outer portion of the shoot and the edible portion is the soft white interior (Barth 2018). Then the shoots are washed and then carefully cut to expose more of the edible portion of the shoot. Roughly 27% of the shoot is edible (Satya et al. 2009). It is best to boil the shoots as soon as possible or else they develop a bitter taste (Barth 2018). The shoots are then boiled in a solution of



brine (3%) to prevent discoloration and reduce toxicity (Singh & Das. 2011). Some processing recommends the boiling water be changed every 10 minutes and returned to a boil and repeated until the shoots are tender (Barth 2018). The shoots of certain species may be steamed or soaked in salt water solutions to remove toxicity as well.

Japan uses bamboo shoots to make takenoko gohan, a simple dish made from young and fresh bamboo shoots and rice cooked in dashi stock.

Fermentation of bamboo shoots yields a variety of finished products including pickled, canned, wine, and other alcoholic fermentations. These are often traditional practices of preserving bamboo and heavily surrounded by cultural history and traditional cuisine. Menma is made from dried bamboo and is used in Japanese cuisine for ramen and noodle soup. Bamboo shoots can also be used to make gulai rebung, an Indonesian dish made from thinly sliced bamboo boiled in thick coconut milk, or santan. In India shoots which were harvested late and have become more fibrous are made into hendua, a garnish made by fermenting and drying shoots before grinding them into a coarse powder (Singh and Das. 2011). Bamboo is commonly pickled as well (Choudhury et al. 2010). Bamboo vinegar is another example of a fermented product which can be made from bamboo shoots; it is used for cooking but also has medicinal purposes as well in Chinese cuisine (Singh and Das 2011). Bamboo wine, beer, and tea are also popular beverages which can be made from bamboo shoots although they may alternatively be made from the sap or the leaves of the bamboo as well. Bamboo shoots may also be used in the production of candy, chutney, and curry (Kendra 2008).



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Cucumbers: Kind of a Big 'Dill'

By Cierra Ortiz

Cucumis sativas, more commonly known as cucumbers is part of the family Cucurbitaceae, which includes “98 genera and about 975 species of food and ornamental plants” like squash, pumpkin, zucchini, and some gourds (Cucurbitaceae, 2017). This plant is thought to have originated in India, where it was cultivated for more than 3,000 years before spreading to China, Greece and Rome. The Romans then introduced it to Europe and Columbus brought the seeds with him on his voyage to America (Infoagro). Today China is the leader of cucumber production, followed by Turkey and Iran. Cucumber is a vegetable according to the definition adopted by the horticultural community, that “everything that grows on an herbaceous plant is a vegetable” (Cucumber- Fruit...). There are three main types of cucumbers: slicing, pickling and specialty heirlooms.

Slicing cucumbers are long and straight cucumbers that are bred for “fresh eating”. They have thin and non-bitter skins which don't need to be peeled and have later seed formation. “Burpless” cucumbers are specific slicing cucumbers bred to produce less of a chemical which releases gas in the stomach (See Figure 1). Pickling cucumbers are the shorter with more spines, and drier flesh to allow more absorption of the brine they are pickled in (See Figure 2). Lastly, specialty cucumbers include varieties like ‘Lemon’ and ‘Sweet Armenian’, and greenhouse cucumbers which require no pollination to set fruit. They tend to produce later and have a less developed disease resistance than other varieties like modern hybrids. They are still grown for their flavor, color, or other characteristics (Cucumber Varieties). (See Figure 3) As you may already know, cucumbers have many beneficial nutrients. For example, their magnesium, potassium and silicon make them great for skin. Interestingly, cucumbers contain antioxidants and flavonoids, and this plus their cooler internal temperature make them great for reducing puffiness, also (Ten Facts).

As far as merchandising goes, cucumbers can be cross-merchandised with other vegetables, bagged salads, or even canning jars and spices. They are also available all year which allows for “ample promotion”. According to a produce market guide, this vegetable can be promoted in different seasons for different purposes as well. For example, in fall cucumbers can be used as a healthy snack for back to school, winter time brings the opportunity to jazz cucumbers up for holiday celebration and inclusion in soups or salads, and lastly for spring and summer, salads are more relevant, and cucumbers can be used in “grilling displays and picnic promotions” (Bogash, et al. 2010).

In the U.S. in 2017, there were 123,600 acres of cucumbers harvested at a value of \$441 million. Although the U.S. is not a leading producer of cucumbers, sales continue to climb, up 6.1% on a 4.5% increase in volume, along with a per pound price increase (Commodity: Cucumbers).

Many people enjoy pickles at family cookouts or even just as a snack on its own, but many don't know the rich history behind pickles at how they got so popular. Pickling foods allowed for long preservation which was highly important around 2030 BC when they came to be in the Tigris Valley of India. The word “pickle” is actually a combination of the Dutch word for salt “pekel” and the northern German word for brine, “pokel”, which are both crucial to pickling.

Pickling is the immersion of a fresh fruit or vegetable in an acidic liquid or a saltwater brine until they are no longer vulnerable to spoilage (), in our case pickled cucumbers which are “lacto-fermented” in a saltwater brine. By doing this, the vegetable develops lactic microbial organisms which transform the natural sugars into lactic acid which turns the environment acidic halting the multiplication of spoiled bacteria. Perhaps the most common pickle is the dill, which originated among the Jewish population in Ukraine, Poland, Lithuania and Russia where they were utilized to

carry families through the winter time until spring when the new crops of produce were available. America was first introduced to the Dill by eastern European immigrants in New York City in the 18th and 19th century.

Perhaps the weirdest piece of information I discovered when doing pickled cucumber research, was that of the Christmas pickle. The idea is that in Germany, parents hung the pickle after the rest of the ornaments made their way onto the tree, and in the morning the first child to find it would receive an extra gift from St. Nicholas or the first adult who finds the pickle gets good luck for the whole year. However, this tradition has been discarded as a myth and it is said on German way article that Germans have even heard of the supposed legend as well as the obvious flaws in the legend like this event taking place on Christmas Eve, but German St. Nick makes his rounds on December the 6th.

When it comes to pickles, the U.S. is a major contributor to the pickle market's growth, holding the highest market share of 47.43%. Although, the industry is scattered. There is a steady level of competition among international and regional players and with many varieties, flavors and differing ingredients, there is a huge market. Like other vegetables, this market is largely influenced by aspects like health benefits, taste and "demand of food complimentary products". However, the increasing popularity of non-GMO or organic pickles and innovative pickle products focusing on health concerns show opportunity for the exploitation of the market.

Although the U.S. currently leads the world in the pickle market, the APAC region is projected to experience a high growth rate on the demand side, perhaps suggesting new involvement on the market level, due to the idea that vegetable pickles are "consumed as an accomplishment". Even though there is a lot of competition among the pickle market, the top ten manufacturers control more than 30% of the market.



Figure 1- Slicing Cucumber



Figure 2- Pickling cucumber



Figure 3- Specialty cucumber (Lemon)

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(Photo Courtesy of Wonderopolis 2018)

Pungent Peppers

Sarah A. Peak

Capsicum is an angiosperm in the *Solanaceae* family, subfamily Solanoideae, of the order Solanales. As part of the nightshade family, *Capsicum* is directly related to tomatoes, potatoes, eggplant, and some highly toxic ornamental plants dangerous to both humans and wildlife (Morgan 2011). Genus *Capsicum* is comprised of a vast quantity of edible and inedible species differing in size, shape, pigment, and pungency. *Capsicum* or “pepper” plants are perennial (though often grown as annuals in colder climates) and herbaceous. Though they are shrub-like in appearance, they are not true shrubs as they are not “woody” (De 2003). The pepper plant’s campanulate white, yellow, or greenish flowers are born singly or in small clusters and are unique in their bluish colored stamens (*Capsicum annum...* 2018). Commercial cultivars are determinate and grow erect, often reaching heights of 1.5 meters (Swiader & George 2002). Although technically a fruit (specifically a berry), peppers are most often eaten as a vegetable, both fresh and cooked, or as a spice in dried or powdered form (Fruit or Vegetable... 2018). Genus *Capsicum*

contains an enormous variety of fruits and varies as widely in pungency as it does in consumption and application. The core eudicot, native to southern Brazil and eastern Bolivia, has been in cultivation for more than 9,000 years (*Capsicum – History...* 2018). All plant species of *Capsicum* are warm season crops (Swiader & George 2002)

The plant's name, *Capsicum*, has an interesting past and today its origin is difficult to confirm. It has been speculated that the genera name, *Capsicum*, may have been derived from *capsa*, the Latin word for "box," particularly boxes that are "smaller than a shoebox," likely denoting the *Capsicum* fruit itself (*Capsa...* 2018). The source of the word is also thought to be a reference to the Greek word, *kapto*, which loosely translates to "to bite, to swallow, or to catch" as well as "prey or seizure" (*Kapto...* 2018). However, as tropical South America is thought to be the motherland of *Capsicum*, it would be logical to assume that the plant's varieties would be known by different names throughout one of the most linguistically diverse areas on the planet (Thompson 2013). The word *chilli* itself is an Aztec expression connected to a *Capsicum* variety that has been in cultivation since 3000 BC (*Capsicum...* 2018). The name has been in use by indigenous peoples of Central and South America long before the time when Columbus visited the new world at the end of the fifteenth century. Thus, the name "chilli" (or "chile" in Mexico) was born thousands of years ago and then passed on (*Capsicum...* 2018), resulting in considerable ambiguity involving the name within scientific literature from different countries.

During his visit to the new world at the end of the 1400s, Columbus "discovered" *Capsicum* and returned to Spain with plants and fruit having already named them "red pepper" for their likeness in pungency to *Piper nigrum*, or "black pepper" (De 2003). From there, it is thought that peppers

were introduced to India by the Portuguese and were then passed on to China, South Asia, and Africa (De 2003).

The most significant species of peppers in cultivation today are *C. annuum*, *C. caccatum*, *C. chinense*, *C. frutescens*, and *C. pubescens*, yet it is theorized that there are as many as fifty thousand *Capsicum* plant cultivars in propagation across the globe (List of *Capsicum*... 2018). Peppers are further separated into horticulture groups based on physical characteristics. The principle groups are: Bell, Anaheim, Jalapeno, Cherry, Wax, and Tabasco (Swiader & George 2002). The species of *Capsicum* most recognized in India, China, and South Asia are the long and thin varieties of mild to moderate pungency known as *Capsicum annuum*. The extremely spicy varieties, having small fruits (such as bird chilies) from the *C. frutescens* species, are now more frequently recognized in Africa (De 2003). Today, chilies are commercially grown in virtually every tropical region and otherwise in almost every climate that will support them annually or perennially (International Pepper Commission... 2014).

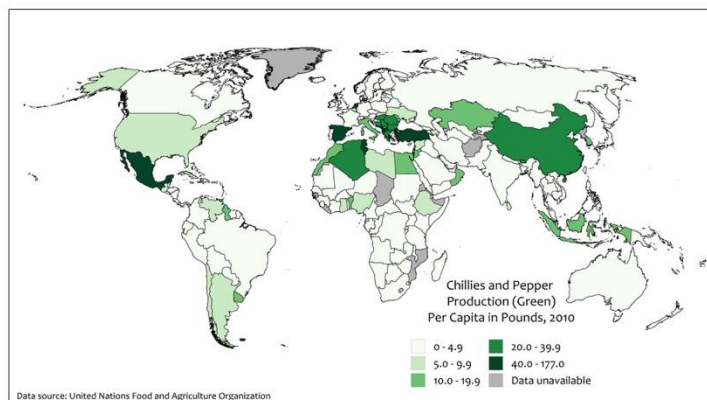
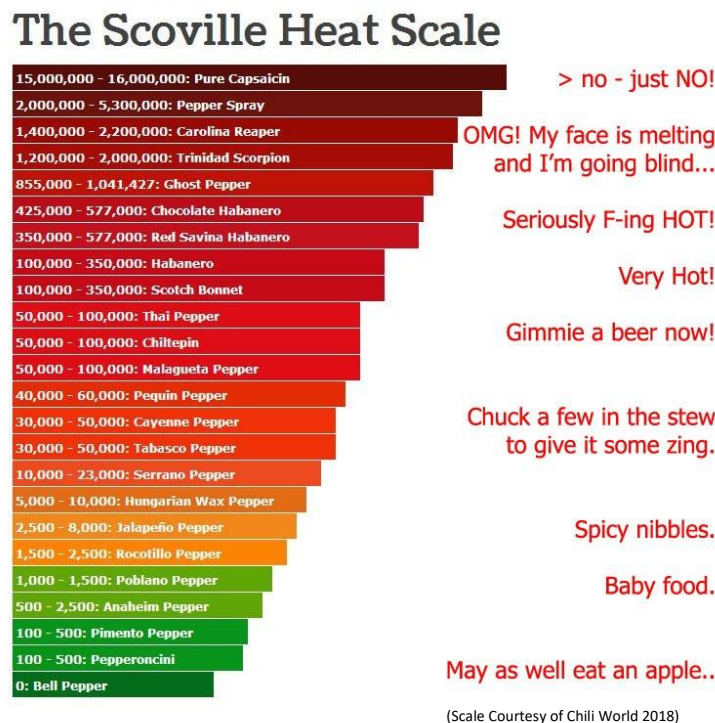


Photo Courtesy of fao.org 2014)

The spiciness of peppers is determined by Scoville heat units. The Scoville scale ranges from 0 (no spice) to 3.18 million Scoville units. To date, the hottest pepper in the world is known as “Pepper X,” created by Ed Currie, owner of PuckerButt Pepper Company in Fort Mill, South Carolina, who also cultivated the famous Carolina Reaper Pepper, now number 4 on the Scoville Scale at 1.5 million to 2.2 million Scoville Heat Units (The Scoville... 2018).



As a consumable, chilies are used both raw and dried, whole and ground, pickled and sauced, and are even used as a food coloring (Ratnala 1999). However, chilies do not just add spiciness to cuisine, they also contain an impressive list of disease preventing and health promoting properties. Protein, folates, pantothenic acid, pyridoxine, riboflavin, thiamin, Vitamins A, C, E, and K, potassium, calcium, iron, magnesium, manganese, phosphorus, zinc, and carotene, just to name a few! Not to mention, chilies contain the alkaloid compound capsaicin, which not only gives peppers their pungent flavor, but also holds anti-bacterial, anti-diabetic, anti-carcinogenic, analgesic, metabolism boosting, and LDL cholesterol reducing properties (Nutrition... 2018).

Capsaicin is known for reducing certain types of pain and is used in over-the-counter topical creams and ointments for arthritis, muscle, joint, and nerve pain (Capsaicin Topical Uses... 2017). Another less well-known chemical in chilies is oleoresin-1, a natural extract of *Capsicum annuum*. It is also used for pain relief, but it can be used as a flavoring agent in cheese, orange juice, candy, and processed meats as well. The Chinese use the leaves of the chili plant to relieve toothaches; Sumatrans use extract of chilies to treat gastrointestinal ailments and cholera; Javanese use the juice of chilies on skin to ease the pain of childbirth; and Indians have been known to use chilies during exorcisms to banish the “evil eye” (Ratnala 1999). Pure capsaicin is dangerous and is the primary ingredient in pepper sprays used for defense (Some Like It... 2018).

In 2017, India was the world’s leading producer, consumer, and exporter of chili peppers, followed closely by China (Dhanushkodi 2017). In the US, Chili peppers are incredibly popular and can be profitable as an agricultural crop. In 2017, the US averaged a consumption rate of 7.7 pounds per person, a number that increases each year. In 2016, the overall US chili pepper production was 4.7 million pounds, grown on 20,000 acres, and valued at \$162.85 million (NASS 2017). While the overhead involved in growing chili peppers can be costly, the estimated gross value of a chili pepper crop stands to be well worth the effort (USDA 2018).

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Sweet Basil

By Sheila Prentice

Ocimum basilicum, or sweet basil, is a common annual herb that is grown around the world. It can be classified as a vegetable crop, based on its culinary uses. Basil is typically propagated from seed in the beginning of springtime, after chances of frost are very low. Seeds can also be started indoors four to six weeks before the plants are moved outside to shorten production time. Under favorable, warm conditions (more than 50 degrees F) basil can germinate in five to seven days (Mahr, 2003). One method for starting basil seeds indoors would involve germinating seeds under an LED or fluorescent light. Soil should be well drained, but should be kept consistently moist. When seedlings reach about two to four inches in height, and after the danger of frost passes, the plants can be transplanted in the ground or into a container outside. Basil can be grown indoors, but as it requires at least eight hours of direct sunlight, supplemental lighting may be needed.



Figure 1: *Ocimum basilicum* (plants.usda.gov, 2018)

Basil is a member of the Lamiaceae family. The species is native to tropical Africa and Asia, and can be grown in plant hardiness zones 2-11. As a warm season plant, basil performs best

in temperatures between 80-90 degrees F. It should be grown in full sun, in moist but well-drained soil (*Ocimum*, 2018).

Common cultural practices for sweet basil include pinching of terminal buds in order to encourage densely branched plants and removing flowers to promote vegetative growth. Plants that begin to develop woody stem tissue can be cut down to about one-third of the original size to promote rejuvenation from the base. When ready to harvest the herb, leaves can be removed individually or sections of stem with multiple leaves attached can be cut off at any time throughout the season. Before the first frost of the year, either harvest the remainder of the plant, or cover completely to protect tender leaves (Mahr, 2003). Since basil is difficult to store, it is best to use as soon as possible after harvest. It should be kept in a room temperature area, with the stem sitting in water to combat wilting. If not using the herb fresh, leaves should be dried by hanging upside down in a paper bag located in a cool, dark place.

As a warm season herb, sweet basil faces danger of chilling injury before and after harvest. Because of this, basil generally does not transport or store well. Symptoms of chilling injury include lack of glossiness, brown and black lesions on leaves, necrotic tissue formation, wilting, and abscission of leaves. Basil that undergoes this type of injury is open to colonization by bacteria and fungi, leading to soft rot. To reduce the chances of damage due to cold temperatures, basil should be stored in high humidity conditions, and care should be taken to reduce mechanical damage and maximize ventilation (Aharoni, et. al, 2010).



Figure 2: Basil with frost damage (hartfordquality.com, 2012)

There are many different cultivars of *Ocimum basilicum* including: ‘Genovese,’ ‘Purple Ruffles,’ ‘Red Rubin,’ ‘Spicy Globe,’ and ‘Sweet Dani,’ to name a few. These cultivars can be used fresh or dry to season a number of culinary dishes. Essential oil made from sweet basil is also very common, and is often used in aromatherapy. It is believed that basil plants surrounded the tomb of Christ after he was resurrected (*Ocimum*, 2018). Greek Orthodox churches still employ basil in the preparation of holy water. Similarly, in India, the herb was used to swear oaths on in court, as it was thought to be “imbued with a divine essence” (*Ocimum*, 2018).

Since basil is a specialty crop that makes up a very small portion of the total industry in the United States, there is a lack of data about yearly production acreage or sales data. It is difficult to find numerical data even for the entire category of fresh herb production. I imagine this is due to the fact that basil is grown by mostly smaller, diversified growing operations. This may be related to the difficulty involved with storing and transporting the herb for fresh use.

I chose to investigate sweet basil because it is one of my favorite herbs, both to grow and to eat. 'Genovese' basil was one of the first plants I grew from seed, and I was amazed by how quickly it developed, and by how much use I got out of the fresh leaves. I now grow at least two cultivars of basil in my garden each year, and I try to keep the earwigs off of it as best I can. My favorite use for the leaves are in fresh summer salads with my garden grown tomatoes, mozzarella, prickly pear infused balsamic vinegar, and a bit of pink himalayan salt. After growing the herb in my home garden, I find it hard to justify buying it from the grocery store. In the future, I would like to have a year-round indoor herb garden under LED lights. Basil tops the list of greens I will produce when I have the space to make this dream happen.

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Pumpkin Fact Sheet, *Cucurbita sp.*

Mira Pusateri

Pumpkins are a cultural icon in the United States. Pumpkins are a staple during Halloween when they are used for carving Jack-O-Lanterns. Jack-O-Lanterns historically were an Irish tradition, used for preventing various ghosts and spirits from entering the home. (Devon 2012) The word pumpkin comes from the greek word “Pepon” that means “large melon” However, pumpkins are actually part of the gourd family. Pumpkins are considered by many to be vegetables because of their mild and savory taste, but botanically they are actually fruits as they contain the seed of the plant. In this essay, I will be discussing the growing habits, history, and cultural impact of pumpkins.

Pumpkins are herbaceous annual plants. Planted in the spring, they need full sun and moderate amounts of water and maintenance. Pumpkin plants are vining and can reach almost 2.5 feet tall. They should be planted approximately 3 feet apart. (Dainello 2001) Pumpkin plants thrive in warm humid conditions



Figure 1; Historical drawing of pumpkin anatomy Missouri Botanical Gardener (2018)

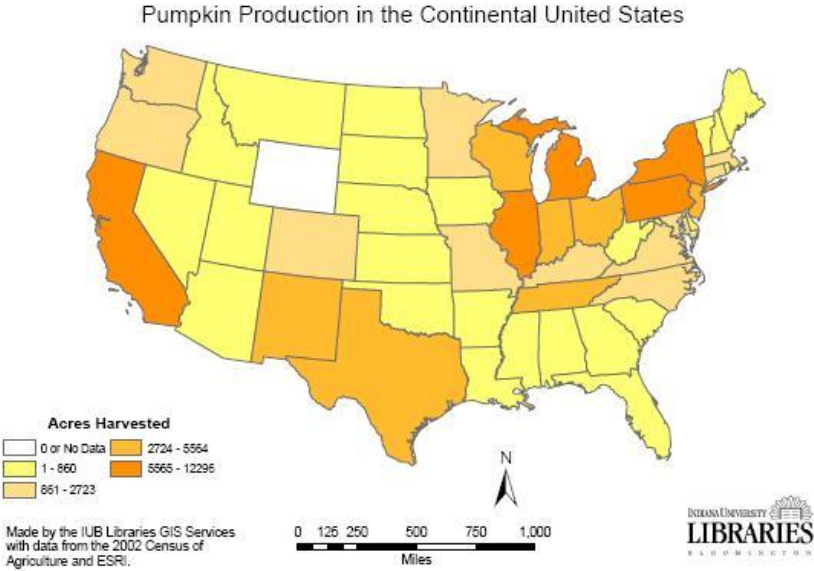
and bloom from July to August. Pumpkin plants are monecious, meaning there are male and female flowers on the same plant. The flowers are large and range from yellow to orange in color. The leaves are described as dark green to yellow with grey markings. Stems and leafs can be covered in fine prickles, a defense mechanism against

herbivorous insects and animals. Pumpkins are harvested at two stages of maturity. Summer squash/pumpkins are harvested at an immature stage while the seeds are still soft. Winter squash/pumpkins are eaten at maturity. In this paper, we will focus on summer squash/pumpkin.

Pumpkins are one of the oldest domesticated plants. Pumpkin/gourd seeds have been found and are estimated to have been domesticated around 7,000 - 5,500 B.C. (Popular Science 2018) Originating in Northern Mexico, they were introduced to the United States, Canada, South America, Italy, France, Kazakhstan, and India among various other countries. China is the largest producer and consumer of pumpkins. They produce almost half of the global pumpkin production. India previously was the largest producer of pumpkins,

Figure 2; Distribution of pumpkin production in the United States. Indiana University Libraries (2002)

but was surpassed by China in the late 1990's. (Financial Times 2018) The United States produces pumpkins as well, but it is the largest importers of pumpkins. The United States mainly imports pumpkins from Mexico, but there is pumpkin production within the continental United States. Illinois is the number one pumpkin producer in the United States, followed by California. In 2005, Illinois produced \$4.97 million pounds of pumpkins. California produced \$1.6 million pound. Over 70% of Illinois' pumpkin production goes directly to



pumpkin pie filling while almost 100% of California's pumpkin production becomes fresh produce. (Pumpkin Patches and More 2018) The state with the highest value of pumpkin production is Ohio with a value of \$26.1 million. There are several factors that affect the amount of yield commercially. In 2005, hurricane Katrina devastated many farms that have yet to be re-established. Unexpected frosts, droughts, floods, and pests have also had a large effect on yield and price. (Pumpkin Patches and More 2018)

There are several varieties of pumpkins produced and sold. Pumpkins are bred for size (miniature to giant), skin color and smoothness, uniformity of harvest, vine growing pattern (compact or thick stems), seed size, and flesh flavor. Cultivars "Small Sugar" and "New England Pie" are commonly used for pumpkin pie filling. Some of the most popular pumpkin cultivars for pumpkin carving are "Autumn Gold" and "Aspen". However, The industry standard and most popular cultivar is "Howden Field". "Howden Field" was developed by John Howden in the 1970's and has become a staple in the modern pumpkin market. It is used for both pie filling and carving, and weighs on average 25 pounds. Pumpkins grown for extreme size are typically derived from the cultivars "Atlantic Giant" or "Prizewinner".

Pumpkins are bred for a variety of traits. Typically, plants are bred for disease and pest resistance, heat and drought tolerance, vine length, sex expression, fruit yield, thick flesh, and flesh nutrition. To achieve this, Breeders will hybridize the three most prevalent species of *Curcubita* (C.). These include *C. pepo*, *C. maxima*, and *C. moschata*.

C. pepo is believed to be the oldest domesticated species of pumpkin. *C. pepo* has a vast amount of morphology within the species. Fruit can range in color from dark green, pale and bright yellow, bright orange, white, and can have stripes or veins. Shapes range from

round to long and thin. The skin can be smooth or bumpy, and may be grooved. *C. pepo* is used to make visually appealing pumpkins for carving as well as consumption.

C. maxima is a species that is used more commonly for fresh consumption due to its higher calcium content. They are also used for their bush habit, compared to a vining habit. *C. maxima* is a very diverse species originating from the wild relative *Curcubita andreana* in South America. (Suzanne Stone Department of Horticulture 2012)

C. moschata is a recently developed species. (Whitaker 1975) *C. moschata* is a well adapted crop. It has greater heat and humidity tolerance compared to *C. pepo* & *C. maxima*, and show a greater resistance to disease and insects. (Hazra et al 2007) Most commercial made pumpkin pie mix is made from a cultivar of *C. moschata*. Using these species and their unique characteristics, breeders are able to breed unique cultivars with a wide variety of traits.

In nature, *Curcubita* species are cross pollinated. In a greenhouse setting, plants are typically hand pollinated by breeders to ensure the desired cross or self pollination is achieved. Typically, inbreeding crops leads to a loss in vigor due to a loss of genetic diversity within the population. However, studies have shown that *Curcubita* doesn't suffer from loss in vigor when inbred, so it is a common practice among pumpkin breeders. Inbreeding is used to promote uniformity, increase yield, and allow for combination with other inbred lines. (Damarany 1989) When a breeder is focusing on developing a single qualitative trait such as disease and pest resistance or growth habit, a backcrossing technique is typically used. A qualitative trait is a trait that is either expressed or not expressed, and is not affected by environment or care techniques. A qualitative trait pumpkin plants are typically bred for includes resistance to pathogens such as powdery mildew, fruit blotch, and mosaic disease. (Langston 2001) Backcrossing

involves breeding a wild species of the plant with the developed hybrid. The same traits can also be achieved using transgenic cultivars and techniques. Transgenic crops are plants that have had foreign DNA artificially inserted into their genome through genome editing or gene introduction using agrobacterium.

Micropropagation is used to clone desired hybrid plants. This is done by taking a small piece of a shoot tip and transferring it into a nutrient rich medium to stimulate new growth.

Micropropagation is used to quickly propagate a desired plant, which is useful for breeding for quantitative traits such as fruit size. A quantitative trait is a trait that is influenced by genetics as well as care techniques and the environment. Plant growth regulators are added to promote the number of shoots and roots development. Plant growth regulators typically used include Benzyladenine (BA), Indole-3-butyric acid (IBA), and Naphthaleneacetic acid (NAA). BA initiates and accelerates cell growth. IBA and NAA stimulate root formation.

Around the time when humans arrived in the Americas, pumpkins narrowly avoided extinction. The changes in climate and over hunting of native mammals (the plants main mode of seed dispersal) forced the native pumpkin species into a decline. However, human domestication significantly helped the survival of pumpkin plants. Plants were chosen for their tasty flesh, large fruit, soft seed, thin skin, and appealing appearance,

resulting in our modern pumpkin cultivars. Without this domestication of ancestral pumpkins, we may not have pumpkins today. (Popular Science 2018)

Competitive pumpkin growing is a worldwide phenomenon. Growers produce extremely large pumpkins that can reach well over 2,000 pounds with hopes of breaking the world record. The current world record is held by Belgian grower Mathias Willemijns. In 2016, he grew a 2,624.6 pound pumpkin. (Modern Farmer 2015) Giant pumpkins need extensive care. Growers choose pumpkin cultivars known for their large size to increase the

probability of large fruit. Growers have to focus on a single flower on a plant, removing all other flowers and fruit. The fruit must sit on dry soil or sand to prevent rot. They need to be carefully protected from wind and sun, and are lightly fertilized every week. Fertilizer should be heavy in nitrogen during the



Figure 3; Mathias Willemijns with his record setting pumpkin. Washington Post (2016)

vegetative state. Once the plant reaches reproductive stage one should switch to a phosphorus heavy fertilizer to promote blossom production. When the plant begins to produce fruit, a potassium rich fertilizer should be used to produce large and healthy fruit. The stem connecting the plant to the fruit must be protected as well as they can become brittle and prone to breaking. After months of intensive care, one can expect a hefty yield.

In the United States, large orange pumpkins are a staple during Halloween. According to a poll by Lendedu.com, those spending money for Halloween will spend over 20% of their money on decorations including pumpkins. Pumpkins are carved and a light is placed inside the hollowed fruit, acting as a lantern. The tradition is believed to have

started in Ireland. The Gaelic holiday of Samhain is where modern day Halloween is believed to have come from. (Cindy 2012) Samhain is a time in which the spirits roam freely. Carved pumpkin, gourd, and turnip lanterns were used to thwart off evil spirits as well as guide the spirits of ancestors into one's home.

The name jack-o'-lantern comes from the story of Stingy Jack.

Stingy Jack was known as a lying drunk. One day, Jack was confronted by Satan. Satan was there to take Jack to Hell, but Jack requested one last ale before being taken away. When confronted with his bar tab, Jack asked Satan to turn into a coin so he

could pay. Once Satan turned into a coin, Jack put him into his pocket next to a crucifix, forcing Satan to remain a coin. Jack said that if Satan wanted to be freed, Satan must spare his soul. Satan agreed and was set free by Jack. Eventually, Jack died from his excessive drinking habits. When his soul made it to heaven, St. Peter denied Jack access to Heaven due to his deceitful lifestyle. When Jack was sent to Hell, he was denied entrance to Hell as well. Jack was stuck between Heaven and Hell. Jack was left to wander the Earth only guided by the light of a pumpkin lantern. (Cindy 2012)

Besides being used as a holiday decoration, pumpkins are used for food and medicine. Pumpkin pie and pumpkin spice flavoring are popular in the United States during Fall. In Central and North America, pumpkins and other gourds are used for simple homeopathic medical treatments. The sap and the flesh of the pumpkin are used to soothe burns, and the seeds are used as a deworming treatment as well as a diuretic. (Medical News Today 2018) In India, pumpkins are used to treat a wide variety of



Figure 4; Illustration of Stingy Jack. Raychel 2017

ailments. Consuming the flesh is used to help with dehydration and fatigue and is said to help with blood purification. The flesh is also said to have antistimulant properties when applied topically. The leaves are said to have many benefits when consumed. They are said to be a painkiller, nausea remedy, and can cure fevers and bronchitis. The leaves are also said to boost hemoglobin levels in the blood, increasing the blood's ability to carry oxygen. Pumpkins contain nutrients such as beta-carotene, potassium, vitamin C and E, and fiber. They also contain unsaturated fats and antioxidants which are beneficial to human health. (Medical News Today 2018)

Pumpkins were saved from extinction by humans. (Popular Science 2018) They have cultural significance around the world, from decoration to folklore. Pumpkins have many health benefits and are said to have many medicinal uses. Growing pumpkins as a sport growing in popularity. In conclusion, pumpkins have been a significant part of human history and will continue to be an important part of vegetable production

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The Garden Radish

By Shianne Quintana

Introduction

When you make your next trip to the grocery store, remember to grab a fresh bunch of *Raphanus sativus* for the salad. While many are familiar with the garden vegetable radish, or *Raphanus sativus*, most people probably consider the radish to be an edible root, however might be surprised to find it is a swollen, underground stem. According to a collaborative effort of national vegetable industry groups, the name Radish, is “derived from the Latin words ‘radix’ meaning root, and ‘raphanus’ meaning easily grown” (Bruin, 2018). Furthermore, the horticultural definition of vegetables as articulated in class is “crops that are eaten either cooked or raw as part of a main meal” (Uchanski, pg. 4). While Radish can sometimes have a peppery, spicy, and crisp taste; having high water content and low nutritional value, radish can make a zesty addition to a salad, sandwich, or enjoyed as a fresh snack, as well as have “phytonutrients that are also found in broccoli and cabbage and anthocyanins in the red skin” (Bruin, 2018). I chose to research the garden radish because it is the crop that I grew in the Student Education Gardens at CSU and would like to know more about it.

Information

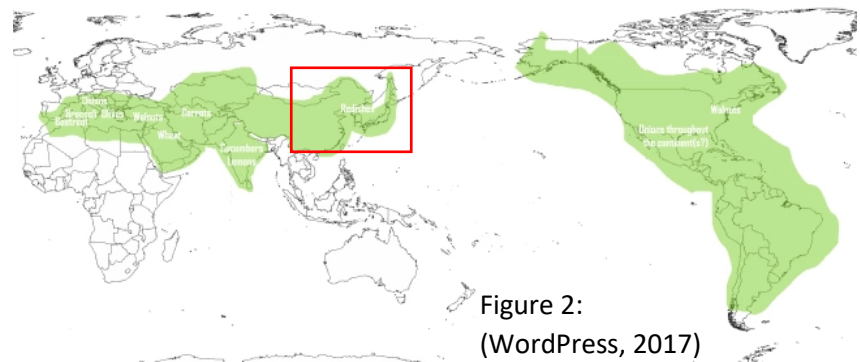
Raphanus sativus belongs to the family Brassicaceae which is also known for broccoli, wasabi, and horseradish according to the Missouri Botanic Garden website (Plant Finder, 2018). There are many different cultivated varieties of the radish; in colors ranging from black, to white, pink, purple, and many combinations in between, also available in a variety of different shapes and sizes. The

Figure 1:



wide variety of radishes cultivated can be seen in Figure 1 above. Additional radish history research shows that radishes were an accidentally discovered vegetable and thought to have originated “between the Mediterranean and Caspian Sea” with first domestication in Asia and Europe (Yang, 2009). The center of origin for Radish is indicated with the red box in figure 2.

Furthermore, in accordance with the same source, vegetables were said to be depicted on the pyramid walls in ancient Egypt and served as an essential crop during that time (Yang, 2009).



Importance

While the radish can have different values such as a root vegetable, oil crop, and important cover crop, according to the article by Nishio, (1970) “Economic and Academic Importance of Radish” the economic importance of radish differs between the eastern and western countries (Nishio, 2017). The article by Takeshi Nishio articulates that in the West the radish is grown as a small vegetable within one month, whereas in the Eastern parts, the radish cultivars are commonly known for having increased root size with various root shapes, often referred to as ‘Asian big radish’, and are also grown for “production of immature pods or oil seeds” (Nishio, 2017).

Additionally, radishes also have glucosinolates, which have health benefits similar to those found in other vegetables, including horseradish (Nishio, 2017). These types of health benefits include anti-cancer compounds. Radish production is not only important for consumption as a root vegetable sold for profit but encompasses other important values and uses varying according to different parts of the world.

Domestication and Cultivation of Radish

The first domestication of radish was thought to have originated in Asian and Europe. This was done through the “evolutionary process and human selection of the preferred crop type” (Yang, 2009). Through this process of selection, the crop can display many cultivars that differ in shape, size, color, and taste. Refer back to Figure 1 to see different breeding characteristics for radish. According to the Seed Savers Exchange, and the article “Everything You Need to Know About Radishes”, radishes are insect pollinated outbreeders because they can cross pollinate with any other radishes. In the past, mass selection breeding was used as qualitative characteristics were chosen, while current breeding programs still use mass selection, as well as hybrid, including single and three-way cross as well as double cross breeding (Biology Discussion, 2016). Additionally articulated, the garden radish is an annual or biennial but generally grown as an annual, and are available year round, worldwide. The vegetable is mostly harvested and sold to be eaten fresh, alongside other fruits and veggies while some Eastern cultures cook the radish and consume it as part of the main dish. Figure 3 shows one way that people consume radishes; fresh. Outlets include local farmers markets, grocery stores, restaurants and also commonly grown at home.

Figure 3:



WordPress, 2017

Growing Radish

Planting Depth	½ inch
Seed Spacing	1 inch apart
Row Spacing	12 inches apart
Harvest Time	About 4 weeks (up to 6)
Cold Tolerance	Half Hardy – will survive light frost
Light Requirements	Full sun

An article by Baessler states that the soil requirements for radish to grow best include a moderately fertile media that is loose and well drained (2018). Also, it is recommended that a pre-planting fertilizer is amended into the soil, according to Baessler (2018) An all-purpose fertilizer 10-10-10 is necessary per 100 square feet of garden (Baessler, 2018).

Additional planting suggests sowing (planting into the earth) radish seeds every two weeks throughout the summer for a continuous harvest, up to approximately 2-4 weeks before the expected first fall frost. Through the practice known as thinning, extra radish are removed to give the others more room decreasing competition for nutrition from the soil. In addition to the wide variety of shapes, colors, and tastes, there are also the cultivars for winter but have a longer maturity period. According to Albert (2014) radishes are harvested from the ground by gently pushing away the top soil to ensure the desired size and ease of pulling the whole plant from the ground. Always wash your fruits and veggies after harvest and before consumption! The website goes on to mention that the radishes will keep in in the refrigerator for about two weeks (Albert, 2014).

Conclusion

Being an easy to grow vegetable commonly consumed worldwide; fresh or as a part of a dish, taste and spice of the radishes can depend greatly on environmental factors such as climate, as well as the size of radish or the amount of time allowed for cultivation. According to W. A. Burpee, knowing when to harvest is emphasized, as this will determine the spice and crispness of the underground stem harvested (2018). It was also noted that in warm climatic conditions, the radish grew to be more spicy, compared to colder climatic conditions (Burpee, 2018). These factors should all be considered when picking up radish from the store, farmers market, or growing them yourself. Radish are readily available for a fast, refreshing snack, so next time you are in the vegetable section at the local market, remember to grab a fresh bunch of *Raphanus sativus* for the salad.

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Brassica oleracea var. 'Italica'

Margo Rasmussen

Broccoli, *Brassica oleracea* var. 'Italica', is a member of the Brassica plant family, more commonly known as the mustard family. Broccoli is characterized by its numerous health benefits, found in the heads of edible immature flowers, and therefore is subsequently a common food choice for many across the globe (Mullaney and Weinroth, 2018). This vegetable is native to the Mediterranean region; however, it is now a widely grown crop, with the United States ranking 3rd in the world in production rates (Mullaney and Weinroth, 2018).



Figure 1: *Brassica oleracea* var. 'Italica' (Ware, 2017)

Broccoli originated from a wild form of cabbage, *Brassica oleracea*, yet it has been in cultivation for such an extensive period of time that the knowledge on the origination of this cultivar is few to none (Gray, 1982). Brkic (2008) notes that the first mention of broccoli as a cultivated crop was discovered in France around the time of 1560, however, it was not seen in the United States until the 1920s, and did not reach popularity as a commercial crop until after the culmination of World War I (Mullaney and Weinroth, 2018).

Broccoli is defined as a vegetable, because it can be enjoyed and consumed directly, meaning it can be eaten raw or cooked if chosen. There are two common and available forms of broccoli: heading broccoli, and sprouting broccoli (Mullaney and Weinroth, 2018). Heading broccoli is the more commonly recognized vegetable, a plant with one large green head and a thick stalk. In contrast, sprouting broccoli is characterized by numerous spouting heads and multiple thin stalks (Brkic, 2008). This hardy, cool season vegetable crop is similar to that of cabbage and cauliflower, and the relationship between the crops is seen by their similar production requirements. Broccoli is a rather noteworthy crop when it comes to harvesting, because there are not yet any mechanical harvesting options, therefore each individual head must be hand-harvested. Hand-harvesting is known in the vegetable industry as one of the most labor-intensive parts of production, and can require more than 50 percent of the year's total input of annual labor (Swiader and Ware, 2002). Once harvested, this crop must immediately be placed into a specialized hydrocooler or be packed with ice. This is an important cooling process, because it allows the broccoli to store for a longer length of time, and if broccoli is not cooled, it will lose its dark green appearance (Orzolek *et al.* 2012).

Broccoli, much like other brassica crops, is a hardy cool season vegetable. A crop will be categorized as either a cool season or warm season crop based on its capability of handling frost, and if the crop is able to germinate at colder temperatures (Swiader and Ware, 2002). Being a cool season crop, broccoli is planted in the early spring for a summer harvest, and then again in the late summer for a fall or winter harvest when the temperature is in the range of 45 to 65 degrees Fahrenheit (Swiader and Ware, 2002). Further classification of broccoli shows that it is an annual vegetable, because the crop will complete its life cycle in the span of one season, meaning that seeds will need to be purchased and planted each year.

In addition, broccoli has many cultivated forms including a diverse array of hybrids. A cultivated variety, or cultivar, is a term assigned to crops that require the hands of a human to exist (Swiader



Figure 2: *Brassica oleracea* 'Romanesco' (VegaProduce, 2015)

and Ware, 2002). Romanesco broccoli, *Brassica oleracea* 'Romanesco', is a great example of a unique broccoli cultivar. This variety of broccoli differs from *Brassica oleracea* var. 'Italica' in that Romanesco is a yellow-green color and has many heads that are arranged in a spiraling fractal pattern, and develop into a conical shape (Brkic, 2008). This cultivar has been the center of many scientific research studies. These studies focus on the idea of evolutionary

algorithms that are inspired by nature, such as with Romanesco broccoli. Evolutionary algorithms can be observed by the spiraling patterns found in nature and are used when “dealing with highly complicated optimization tasks” (Jin and Tran, 2010).

Broccoli is an important crop for a multitude of other reasons as well, including its rank as being one of the most commonly consumed vegetables in the United States. Based on annual eatings per capita in 2014, Produce for Better Health Foundation found that broccoli was in the top ten, whether it be eaten directly (raw) or cooked into dishes as an additive or supplemental ingredient (Produce for Better Health Foundation, 2015). Economically, broccoli as a produce is very important in the United States. As of 2010, the total economic value of broccoli in the United States was approximately 648,886,000 dollars (Albert R. Mann Library, 2011). Economic statistics continue to change as the Agricultural Marketing Resource Center recorded in 2017 that, on average, fresh broccoli in the United States sold for \$46.00 per cwt and processed broccoli was

valued at \$388 per ton, or \$19.4 per cwt (Iowa State University, 2018). Most interestingly, when all U.S. grown crop is gathered, 95 percent of it constitutes is fresh crop production, and further, 92 percent of all U.S. grown broccoli is produced in California (Iowa State University, 2018). With this much available broccoli, marketing options are numerous. Most common is fresh market, however there are a magnitude of other marketing possibilities. Marketing of broccoli can range anywhere from wholesale and cooperatives, to a local retailer or even a simple roadside stand (Orzolek *et al.* 2012).

In conclusion, broccoli may pose as just another green vegetable that is often forgotten on the dinner plate, however it is so much more. Throughout the years of cultivation, broccoli has gone from being an unidentified, wild form of cabbage to now ranking as one of the most commonly eaten vegetables (Produce for Better Health Foundation, 2015). Not only are there numerous unique cultivations and hybrids of this crop, but it is a crop that has various health, as well as economic benefits. Overall, broccoli, although difficult to harvest, has proven to be a valuable cool weather crop that is both versatile and interesting.

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Specialty Potatoes

By: Hope Raymond

Introduction:

Solanum tuberosum, more commonly known as the potato, belongs to the family, Solanaceae. Potatoes are a perennial, cool season crop, grown for their nutritious tubers as an annual (University of Illinois Extension, 2018). Specialty potatoes include blue-fleshed, red-fleshed, yellow-fleshed, and fingerling cultivars (University of Maine, 2008).



Figure 1: Assorted specialty potatoes (Potandon Produce, 2018)

Specialty potatoes are considered a vegetable as they are served during the main part of a meal and can be consumed with little to no preparation, such as a light steaming. I chose this vegetable crop because of its unique nutritional content.

History:

Potatoes originate from the Lake Titicaca region of the Andean Mountains, providing a stable food source for many cultures living at high-altitudes (USDA-ERS, 2016). Potatoes were domesticated between 7,000 and 10,000 years ago (USDA-ERS, 2016). The Incan people viewed this vegetable as key to their food security as it was easily consumed fresh or stored via dehydration and freeze-drying methods (USDA-ERS, 2016). This was beneficial in times when other crops failed or were not as storable in their climate. Documentation of

potato cultivation in the United States dates to early colonists (USDA-ERS, 2016). Before the settlement of the west in the U.S., potatoes were predominately grown in New York, Pennsylvania, and Maine. However, they are now widely grown in western states such as Idaho, Washington, Wisconsin, and Colorado (USDA-ERS, 2016). Idaho has led U.S. potato production, processing, and packing for over 50 years (Taylor et al., 2007).

Nutrition:

Potatoes are a source of both vitamin C and potassium, containing about eighteen percent of the recommended daily potassium and half the daily adult requirement (100 mg) of vitamin C. (University of Maine, 2008; NPC, 2018; Colorado State University, 2015) In addition, they are a sodium-free, fat-free, and gluten-free food. Not to mention, they contain vitamin B6, niacin, potassium, and iron (Colorado State University, 2015; NPC, 2018). Potatoes are a source of numerous antioxidants such as polyphenols, ascorbic acid, carotenoids, tocopherols, α -lipoic acid, and selenium (Lahcman & Hamouz, 2005). Potatoes also contain glutathione, an antioxidant that may help protect against some forms of cancer (nationalpotatocouncil.org, 2018).



Figure 2: 'Purple Majesty' cultivar (Burpee's, 2018)

Blue-fleshed specialty potatoes, such as the 'Purple Majesty' (Figure 2), are loaded with these antioxidants. In general, purple potatoes contain higher levels of total phenolics and anthocyanins and they have a larger antioxidant capacity compared to non-pigmented potatoes (Clark et al., 2010) Pigmented potato cultivars contain two to three times higher antioxidant potential in comparison with non-

pigmented potatoes (Lahcman & Hamouz, 2005). To make these valuable nutrients available to your body, lightly bake, steam, or microwave your potatoes (Colorado State University, 2015). Boiling potatoes results in the largest nutrient loss (Colorado State University, 2015). It is commonly believed that a potato's skin contains the majority of nutrients, yet more than 50 percent of the dietary fiber is found within the flesh (Colorado State University, 2015).

Breeding:

Potato cultivar development is a lengthy process that takes more than 14 years, consisting of five main steps (Colorado State University, 2013). Much of potato breeding and selection focuses on reduced Nitrogen and fungicide inputs for enhanced postharvest and processing qualities such as extended latency (Colorado State University, 2013). Additionally, there is large emphasis on the development of resistant cultivars to an assortment of potato pathogens (Colorado State University, 2013). At the CSU San Luis Valley Research center, pathogens of interest include: late blight, pink rot, nematodes, powdery scab, corky ringspot, and storage rots such as dry rot (*Fusarium* and early blight) or bacterial soft rot. (Colorado State University, 2013)

Planting:

Potatoes should be planted in fertile, well-drained soil (University of Illinois Extension, 2018). Potato seeds are not a traditional seed. Potato seeds are sections of whole potatoes with at least one 'eye,' or growth point (University of Illinois Extension, 2018). Potato seeds should be sown ten to twelve inches apart and covered in a furrow between one and three inches deep (University of Illinois Extension, 2018). It is vital that tubers always remain

covered by a few inches of soil to avoid greening, which may indicate dangerous levels of a glycoalkaloid called solanine (Nebraska Extension, 2018). Most U.S. grown potatoes are planted in the spring and harvested in the fall. However, about ten percent of U.S. potatoes, mostly specialty cultivars, are planted in the winter, spring, or summer (USDA-ERS, 2016).

Harvesting:

Specialty potatoes should be harvested once the aboveground vegetation has died (University of Illinois Extension, 2018). It is important to be gentle when harvesting to prevent tears on the skin, which can greatly reduce storage life (University of Illinois Extension, 2018). When harvesting by hand, a shovel or spading fork is beneficial for digging the potatoes. Although rare with specialty potatoes, mechanical harvesting is also an option. This method of harvesting is uncommon for specialty potatoes because they are often grown on a smaller-scale than other types of potatoes.

Marketing:

Specialty potatoes are primarily bought and sold in the fresh marketplace. The USDA-ERS (2016) suggests that specialty potatoes meet specific market needs and thus are priced higher than commercially produced fall potatoes.



Figure 3: Marketing for Frieda's fingerling potatoes (Frieda's, 2018)

Post-harvest Storage:

Specialty potatoes should be stored in a dry, dark environment. Unlike most produce, potatoes can be stored long-term in climate-controlled conditions (USDS-ERS, 2016). The ideal temperature range for storage is between 45- and 55-degrees Fahrenheit (Colorado State University, 2015). Potatoes that are stored above 55 degrees Fahrenheit may sprout, and those stored below 45 degrees Fahrenheit will convert the starch to sugars (University of Maine, 2008). Therefore, storage in a refrigerator is not recommended for potatoes. Potatoes should not be washed before storage because this promotes mold and reduces storage life (Colorado State University, 2015).

Importance:

The potato is one of the most economically important vegetable crops in the U.S., contributing about 15 percent of all farm sales receipts for vegetables (USDA-ERS, 2016). The U.S. National Agricultural Statistics Service (2018) estimates that over 1 million acres of potato crop were planted in the United States in 2016. Additionally, the potato industry in the U.S. is valued at almost 4 billion dollars (NASS, 2018). Specialty potato cultivars, planted in the spring and summer, are valued at about 6.8 million dollars of the industry (NASS, 2018). The unique nutritional value of pigmented specialty potato cultivars is beneficial to human health in a few aspects. The antioxidant content of pigmented cultivars plays an important role in the prevention of numerous pathological conditions such as cancer, heart disease, and atherosclerosis (Koroulis, 2017).

Conclusion:

Specialty potatoes are unique in several ways. They are full of antioxidants and pigments, which are associated with numerous health benefits. Overall, they are beautifully pigmented and delicious to eat!

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Effects of light sources on the production of doubled haploid wheat embryos

Matias Reynoso

Introduction

In agricultural breeding programs, there is a need for homogeneity and little variation of phenotypic traits expressed by crop plants. Selection of desirable traits over multiple generations can increase uniformity. However, development of a new cultivar through conventional breeding methods can take anywhere from 10 to 15 years (Inagaki, 2003; Niu et al., 2014). The production of doubled haploid wheat is very important for breeding efforts, since the time to obtain a pure genetically homozygous parent to produce hybrid lines is diminished. There are two main pathways to produce haploid wheat, through pollen and anther culture or ovary culture (Niu et al. 2014).

Use of reproductive cells is preferred since cells are haploid after meiosis. In androgenesis, anthers or pollen grains are cultured to regenerate haploid plants. Whereas, in gynogenesis, unfertilized ovaries are used to produce haploid plants. Androgenesis is more widely utilized due to the high number of pollen cells that can be obtained. However, anther and pollen culture cause high rates of albinism in winter wheat (*Triticum aestivum*), which is an undesirable trait (Tayeng et al. 2012; Niu et al. 2014). Ovary culture through wide hybridization using maize is becoming more widespread (Mahato & Chaudhary, 2015). Wide cross hybridization are crosses between two different species in the same genera, family and subfamilies. In the Poaceae family, there is cross-compatibility between the Panicoideae and Pooideae subfamilies (Laurie & Bennett, 1986). Wheat ovules can be fertilized by maize pollen and produce a zygote. Maize chromosomes are eliminated in early development and without artificial manipulation the embryos are aborted. Use of 2, 4-D is necessary to promote zygote development and enlargement to make embryo rescue through culture easier (Inagaki, 2003). Formation of haploid embryos resulting from wide crosses is usually low, with reported percentages of recovered haploid embryos ranging from 22% to 38% (Campbell et al. 2001; Laurie & Bennett, 1986). It has been recognized that increments of embryo recovery rate are necessary (Inagaki, 2003; Weyen, 2009). Furthermore, individual plant genetics, and environmental factors affect embryo development and survival (Campbell et al. 2001; Inagaki, 2003). It has been described that in wheat and maize crosses, higher light intensity ($1000 \mu\text{mol m}^{-2} \text{s}^{-1}$), and lower day and night temperatures had positive effects on haploid embryo development in various wheat cultivars (Campbell et al. 2001).

Novel sources of artificial light technology for horticultural production, such as light emitting diodes (LEDs) have enhanced plant productivity in greenhouse operations. Electricity consumption from production of lights is improved relative to high-pressure sodium (HPS) lights, which are commonly used in greenhouse production. Compared to HPS fixtures, the amount of heat emitted from LED lamps is cooler and directed away from the plants (Särkkä et al. 2017). However, the extent of increased plant productivity from LED use compared to HPS, remains unclear (Särkkä et al. 2017; Davis & Burns, 2016). In this study we compared the production of wheat haploid embryos under two different artificial light sources HPS and LED.

Methods and Materials

In the production of doubled haploid seed, we start by planting F1 seed resulting from the cross of desirable winter wheat varieties. Winter wheat requires exposure to low temperatures in order to break dormancy and flower.

Seedlings are germinated in the greenhouse and then moved to cold storage at 2 °C where they remain for 8 weeks and then planted in 1 gal pots filled with Promix HP with mycorrhiza and biofungicide soil. Plants were moved to the proper greenhouse for doubled haploid production (Santra et al., 2017). For this experiment, 400 seedlings were planted, randomly selected and divided into two treatments.

Half of the wheat seedlings were designated as control and placed in a greenhouse with high pressure sodium (HPS) lamps. The remaining wheat plants were placed in a greenhouse where light-emitting diode (LED) lamps are used. LED lamps used are Philips brand top fixtures, using a combination of red, white and medium blue light, which is the full spectrum of absorbable light for plants (Figure 1). Photon flux for LED fixtures is around $400 \mu\text{mol m}^{-2} \text{s}^{-1}$. Seed was produced from ten lines that were numbered 379-388.



Figure 1. Wheat F1 plants under LED light

The production of doubled haploid wheat seed followed the protocol outlined by Dr. Santra with some modifications. Corn pollen (*Zea mays*) is necessary for the development of a haploid wheat embryo. We use a short and fast flowering sweet corn variety from Canada. To maintain a constant supply of corn pollen, at least 14 pots are planted every week in 3-gallon with 4 or 5 seeds per pot, planting starts three weeks before wheat seedlings are moved from cold storage to the greenhouse. Since corn requires higher amounts of nitrogen and water, we mix Promix HP soil with Greens Grade clay and Osmocote (14-14-14), nitrogen is supplemented every 1-2 weeks with Peters Professional all-purpose fertilizer (20-20-20) (Santra et al., 2017).

Emasculating is the removal of anthers from the wheat florets. Emasculating must be completed before flower anthesis therefore, removal of anthers begins once wheat spikes emerge from the leaf flag and when more than half of the florets are exposed. To expose the anthers, they are cut down and the middle floret is removed, there are three anthers per floret that must be removed completely, without damaging the ovule and stigma, this is done on every floret on the spike. The spikes are then covered with a glassine bag where the line number and date of emasculating are recorded (Santra et al., 2017).

Pollination of the emasculated flowers is performed the day following emasculating. Corn pollen is collected on a petri dish from maturing corn anthers. To ensure maximum viability, pollen must be used within 30 minutes of collection. Pollen is used in previously emasculated spikes once the ovary is mature. One or two days after emasculating, ovaries are checked, when the stigmas are feathery it means it is ready for pollination. Pollen is then placed into the florets

using a soft painting brush, ensuring that pollen reaches the wheat stigmas. The glassine bags are then labeled with the date of pollination and a mark is made above the date to differentiate from date of emasculation (Santra et al., 2017).

Once spikes have been pollinated, the embryo will start developing, however, the plant will naturally abort it. In order for the embryo to grow sufficiently for culturing, a plant growth regulator (PGF) is used 24 to 48 hours after pollination. A solution of 2,4-Dichlorophenoxyacetic acid (2,4-D) Sigma brand is prepared using 213 mg/L and adjust to pH 10.36. A wash bottle is used to apply 2,4-D to each floret. The glassine bag is cut at the upper corners, the bottom corner is folded and stapled to the bag. Airflow in the bag increases and the bag is securely attached to the spike (Santra et al., 2017).

The haploid embryo continues to grow for 16- 20 days after hormone treatment. After the embryo has matured enough, the spikes are cut down and stored in a fridge at 4 °C, they can only be stored for a week or less. If possible sorting the spikes occurs right after harvest, spikes are sorted by line number. Once sorted, haploid seed excision should be started. All the seeds are placed on a petri dish and are kept hydrated with deionized (DI) water. Line number, quantity of spikes, florets and seeds are recorded on the petri dish lid. Haploid seed are small and delicate, so excision is extra care is taken to prevent damage. To expose the embryo, the lemma, palea and glume are opened with forceps and the embryo is carefully pushed and removed. Sporadically, emasculation is not done at the right time and some florets could have been self-pollinated, in which case, seeds will be bigger and with a developed endosperm, these embryos are easily distinguishable and discarded. The plate is stored in a fridge at 4 °C (Santra et al., 2017).

Embryo culture is usually done within seven days after harvesting spikes. Seeds are surface sterilized for one minute with 70% grade ethanol. The seeds are drained and drenched in a solution of 60% bleach and 2-3 drops of Polysorbate 20 (Tween20) for ten minutes, keeping the solution shaking gently. The seeds are then rinsed at least five times with deionized (DI) water. Seeds are then moved to a sterile area to be excised for culture. A dissecting microscope and dissecting kit are used, making sure to flame sterilize instruments several times to reduce contamination. To reach the embryo, the endosperm is cut on the stigma end, and the seed coat peeled back. If there is an embryo present, it will be white or translucent and should be easily located (Santra et al., 2017).

The embryo is then placed in half strength Murashige-Skoog (MS) culture media with the coleoptile facing up and the coleorhiza going into the media (Figure 2). Placement of the embryo in the proper orientation will promote shoot and root development rather than callus production. The rescued embryos are then placed in a dark incubator at 23 °C for up to 2 weeks. After which they are moved into a light incubator at 23 °C, where plants are kept under a 16 hours light and 8 hours dark photoperiod. If an embryo is not developing properly or is too small, kinetin and phenyl acetic acid (PAA) can be supplemented into the media (Santra et al., 2017).

Plants with extensive shoot and root formation are transferred to a cold growing chamber kept at 4 °C, plants are left in cold treatment for eight weeks. Vernalization of haploid plants before inducing doubling of chromosomes increases survival rates of haploid wheat.

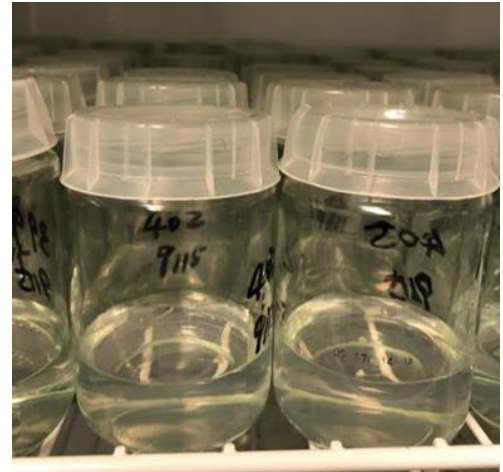


Figure 2. Rescued embryos in culture. (Reynoso, 2018)

After cold treatment, seedlings are transferred to flats with 48 or 96 plugs filled with Promix HP soil mixed with Osmocote. Seedlings can be removed from the flat when they have at least five true leaves, approximately 2 weeks. The soil is rinsed off the roots with DI water and subsequently submerged in colchicine (Santra et al., 2017).

Colchicine is used to double the number of chromosomes in haploid wheat plants. It is a highly toxic chemical and is only used under a fume hood. Must be handled carefully, using personal protection equipment (PPE), like lab coat, closed shoes, and safety glasses are required. Colchicine affects normal separation of chromosomes during mitosis. Disruption of microtubule formation prevents polarization of the chromatids, therefore, impeding natural separation of the chromatids and doubling the number of chromosomes in each cell (Hansen & Andersen, 1998;



Figure 3. Regenerated haploid wheat being treated with colchicine (Reynoso, 2018).

Santra et al., 2017). Colchicine is formulated into a 5% stock solution, colchicine is dissolved in dimethyl sulphoxide (DMSO) 5 grams of colchicine per 50 ml of DMSO. To prepare a working solution, 5 ml of the stock solution is mixed with 15 ml of DMSO, 10 drops of Tween20 and 100 μ l of gibberellic acid (GA3 in 1mg/ml stock solution) are poured into an amber bottle with DI water to make a 1-liter solution. Wheat seedlings are immersed in the colchicine solution and kept under darkness for 12-14 hours (Figure 3). The treated roots are thoroughly and carefully rinsed with DI water and kept in glass containers with DI water. Doubled haploid seedlings were planted into pots within 3-4 hours. Seedling are misted with water 2-3 times a day to decrease desiccation until they can sustain themselves. Plants will reach maturity in approximately 4 months with proper care and nutrition (Santra et al., 2017).

Results and Discussion



Figure 4. Haploid seed recovered from HPS treatment (left) and LED treatment (right) (Reynoso, 2018).

Seed production varied greatly between experimental treatments, however, there were additional variables that could have affected embryo development in both light treatments. For the control group (HPS), we obtained a total of 61 embryos from 10 lines. Whereas, plants in the LED greenhouse produced 1720 embryos in total (Figure 5). There was a significant difference between the number of embryos obtained from the two treatments. However, we cannot conclusively say that the differences in our data were the effect of

environmental lights alone. For the duration of the experiment, at the greenhouse with HPS lighting the temperatures were higher than in the greenhouse with LED lights. It has been demonstrated that high ambient temperatures, over 22°C, have a negative effect on embryo production (Campbell et al. 2001). Moreover, the plants under LED lights were on a bench that stood closer to the cooling pads. Which could have made the temperature differences between the greenhouses even greater. Furthermore, due to differences in the greenhouses, wheat under HPS lights began flowering and self-pollinating before breaking free of the flag leaf, making us lose potentially viable embryos. Additionally, management for powdery mildew was not started on time and both greenhouses were severely affected. Due to powdery mildew, high temperatures, erratic flowering and poor embryo recovery, and to better utilize the space we rent, emasculatation of plants under HPS lights was terminated and remaining treated spikes were harvested at the appropriate times.

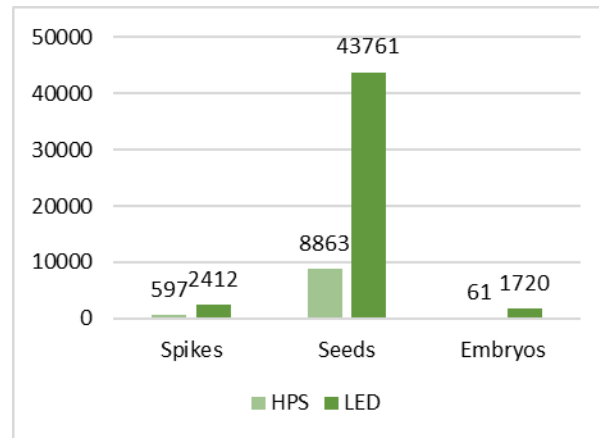


Figure 5. Total number of wheat spikes, seeds and embryos recovered from both treatments.

Conclusion

Using LED lights has shown to increase plant productivity by providing a more functional range of light wave lengths. Moreover, LEDs consume less energy and emit less heat than HPS lights. Based on the data collected, the wheat plants in the LED treatment had a positive effect on haploid embryo production (Davis & Burns, 2016; Särkkä et al. 2017). However, there were other variables that were not constant for both treatments that affected embryo recovery and should be considered in future studies. Repeated experiments in the winter and spring are necessary since haploid embryo development has been shown to be increased with lower temperatures (Campbell et al. 2001).

Acknowledgements

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Pea History and Cultivation

By Matias Reynoso

Sweet peas and snow peas (*Pisum sativum*) are legumes from the Fabaceae family. Peas have been cultivated for centuries, records of pea cultivation and consumption date Egyptians, Greeks and Romans (Burpee, 2018). Genetic studies show four zones have been documented as centers of origin, Central Asia, the Near, East Abyssinia, and the Mediterranean. Peas were introduced to America soon after its discovery in 1492 (Muehlbauer & Tullu, 1997). Peas have been cultivated by humans for 8500 years, earlier records of human consumption date 9500 years ago (Pavek, 2012). Pea plants were introduced to England at the end of the 16th century. The original name for pea in the old English was pease or pise, derived from the latin 'pisum', as shown in this old nursery rhyme: 'pease porridge hot, pease porridge cold.' Eventually, the last two letters were dropped since it caused confusion as to whether the word was singular or plural (Burpee, 2018). Peas have been edged in history and every genetics class thanks to the genetic works of Gregor Mendel (Swiader & Ware, 2001).

Cultivation of peas was originally composed of dry seed only since people believed green peas were poisonous (Muehlbauer & Tullu, 1997). Peas are a cool-season crop and are planted as soon as the soil warms up enough for planting, and temperatures are above 45-50°F



Figure 1. Pea flowers (Pavek, 2012)

depending on variety and cultivar. It is not advised to start seeds indoors to transplant since the delicate roots of peas get damaged very easy and cannot withstand the stress of transplanting (Maranhao, 2014; Swiader & Ware, 2001). Moreover, disturbing the roots will likely diminish

yields later in the season (Burpee, 2018). Peas are usually sown outside four to six weeks before the last predicted frost of the season. Rows are made 1 inch deep for garden and raised beds. In raised beds, rows should be spaced 8 inches apart, and 18 inches in garden beds (Maranhao, 2014). Snow will not typically damage pea plants since it creates an insulating layer, however, if plants are uncovered and temperatures get below 10-14 °F for more than a couple days they will die (Old Farmer's Almanac, 2018; Pavek 2012). Freezing tolerance in peas is determined by the concentration of soluble sugars in leaves (Pavek 2012). Planting peas closely together is recommended since they can outgrow weeds and keep the soil cool (Burpee 2018). Peas need little nitrogen fertilizer since they have Rhizobium bacteria that have the ability to fix atmospheric nitrogen (Swiader & Ware, 2001). Too much nitrogen fertilizer encourages vegetative growth and poor and erratic flower development. Using a fertilizer with phosphorous and potassium, and low nitrogen content will boost flower and fruit production. Full sun and even amounts of water are required for a plentiful yield (Maranhao, 2014). The soil should never dry out completely, particularly when flower and fruit production are ongoing (Burpee, 2018).



Figure 2. Pea pods in a basket (Burpee, 2018)

Supporting the pea vines in gardens is encouraged since it allows for increased pod production and decreased disease pressure. Trellis nets are useful to keep the vines off the soil, alternatively, they can be grown next to fences (Burpee, 2018). Placing supports while plants are shorter than 6 inches is recommended since it can be harder to place supports when the plants are older (Maranhao, 2014). However, in most commercial operations plants are not supported to facilitate mechanized production and harvest. Pea pods can be harvested 50 days after planting. Sugar snap

peas and shelling peas will be ready for harvest when the pods are plump and dark green. Snow peas are picked when the pods are somewhat flat. If the pods start turning yellow it means that the sugars are being converted to starch, and lose much of their flavor (Maranhao, 2014). Regular pod harvesting stimulates continued pod production. Fresh peas cannot be stored for long periods of time because of stored sugars turning into starch, distorting the flavors (Burpee, 2018).

Peas are relatively easy to maintain since most cultivars are bred for disease resistance. Some of the most economically important diseases of pea are powdery mildew, Fusarium wilt and near-wilt, bacterial blight, downy mildew, Septoria blight, and root rots. Chemical



Figure 3. Pea pods resting on fresh peas (Old Farmer's Almanac, 2018)

control for many of these economically important diseases is limited and using resistant varieties, clean and certified seed along with seed treatments and a 4-year crop rotation are commonly used. (Muehlbauer & Tullu, 1997; Swiader & Ware, 2001). Aphids and thrips can be detrimental to the health of peas if not managed early. Most notably are

the insect pests that target the pods and seeds like, the pod smidge (*Contarina pisi*), pod borer (*Diachrysia obliqua*) and others (Muehlbauer & Tullu, 1997).

In conclusion, peas are cultivated for both human and animal consumption. They can be used as manure or cover crop thanks to their fast vegetative growth and ability to fixate nitrogen (Pavek, 2012). Much of the fresh pea production has been abandoned by major producers to concentrate on processing beans for canning and freezing. However, fresh peas are favored particularly by small

gardens and farms (Swiader & Ware, 2001). Major producers of peas in the world are China, India, Canada, Russia, and the United States. In the US, pea production is concentrated in Washington, Montana, Oregon, Indiana, and North Dakota (Pavek 2012). Production of peas for canning is more widespread in the Eastern and Western U.S. Whereas, peas grown in the Western US states are processed for freezing. Dry pea production is concentrated in dryland areas in Washington, Oregon, and Idaho (Swiader & Ware, 2001). Annually, estimated production of peas is 15 million metric tons (Muehlbauer & Tullu, 1997). In 2017 alone, the US commercial pea production was worth \$183,943,000 USD, including, Austrian winter peas, dry edible peas, and wrinkled seed peas (NASS, 2018).

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Fact sheet of Shallots

Taylor Schultz

This fact-sheet covers the plant known as the shallot. Belonging to Alliaceae or the onion family, shallots or *Allium cepa* var. *aggregatum* have been cultivated for thousands of years. Most comparable to an onion, shallots provide great flavor either raw or cooked to many culinary dishes. The following text will provide a more in-depth look into the shallot and why it is used today. The shallot's journey with humanity is said to have begun near ancient Egypt, being traded to India, Persia and the Mediterranean region of the time and were named by the ancient Greeks. The original classification of shallots was within the Liliaceae family as *Allium ascalonicum* (Onion of Ascalon) but later re-classified within Alliaceae as *Allium cepa* var. *aggregatum*. Being traded along with onion, shallots survived the passage of time and are currently being traded at a market average of \$1.86 USD per kg (Tridge, 2016).

Shallots as of 2016 are a \$3.7B dollar market, but they are on a decline from their highest market value of \$4.2B in 2013 (Tridge, 2016). The world's top exporter is the Netherlands followed by China and India. The United States is the largest importer of shallots followed by the United Kingdom and Vietnam (Tridge, 2016). On a much smaller scale, I currently buy onions, shallots, and garlic and use all three as a base flavor for most of my own dishes and I chose this particular cultivar to learn more about it as with interest in new recipes that shallots can be used in substitution or in addition to onion. Identifying shallots can be tough when shopping but most often the shallot will appear as a small onion from a distance with more distinguishing features as you take a closer look.

Anatomically, the shallot is a bulbous vegetable that can be identified from onion by its smaller, tapered shape. Along with a fine-textured and coppery skin. However, identification can become complex when considering region and language. For example, in France shallots are grey and have a stronger flavor but can be traditionally red and purple in Asia. Even more confusing green onion are called shallots in Australia, but these are not the same species and should not be confused.

Although, this confusion could stem from the fact that the shallot can be consumed in its entirety and not just the bulb that grows underground but since green onion is cultivated to have great flavor in the stalk above ground, it does not seem ideal to consume the tops of shallots when the options are available.

This vegetable has made appearances in Asia and is an authentic ingredient used in many Thai, Indonesian and even French meals. The portion of the shallot that is used as an ingredient is its underground growing bulb that grows similar to garlic in clumps or clusters (Catherine D. et al. 2012). The bulb is usually processed before consumption, often cutting off a small section of the top and bottom and removing the outer-most layer of skin and portioning the flesh into the desired size needed for the dish being prepared much like an onion. However, shallots are preferred over the onion for its milder flavor, the shallot has less of a bite and notes of garlic. Shallots can be used in combination with onion and garlic, sautéed, for most soup and sauce bases. A traditional Asian preparation of shallots is to thinly slice and fry the flesh until crispy and use it as a topping on many different meals as garnish to add more flavor and texture. Shallots tend to cook faster than onion, but often do not share the same storage life. Outside of cooking, shallots are said to have medicinal properties and can remedy different ailments.

Shallots have medicinal properties as well as being consumed as a vegetable. They contain an important flavonoid or vegetable pigment that strengthen small blood vessels and reduce permeability, helping to prevent a number of inflammatory diseases (Catherine D. et al. 2012).

Shallots have even been used with the promise of other medicinal effects such as removing freckles, a remedy for the cold, and even a pain reliever. In some scenarios the juice of the shallot is used for an insect repellent and as a polishing agent for copper (Catherine D. et al. 2012).

If these qualities are of interest, starting a personal garden of shallots can be easy. Beginning with the area to plant in, the shallot is most suitable in full sun to partial shade and requires a well-draining soil with high organic matter at a pH of 5 to 6.8. Shallots can be direct-seeded, grown from bulb, or even from transplants started inside. When direct-seeding sow it ½ an inch deep and ½ - 1” apart to produce single bulbs. If clusters of bulbs are desired, increase the spacing between four and six inches. Most people produce a single cluster from seed and the bulbs are separated and planted again to produce more clusters. It is recommended to begin planting two to four weeks before the average last frost. In northern Colorado the last frost would be approximately May 5th. Shallots, along with onion, is a cool season crop that matures best between 55° F to 75° F and can tolerate mild frost (Diane R. et al. 2015).

It is recommended to keep the garden as weed free as possible to ensure proper growth of the shallots and to prevent resource competition. Shallots are ready for harvest when the above ground vegetation wilt and the bulbs will begin to protrude from the soil, with the skin becoming papery. Harvest is as simple as pulling the bulbs from the ground removing excess soil and removing the top portion from the bulb as it will become dry and separate. With the longest shelf life of the shallot being a month in optimal conditions, it is recommended to store shallots in a cool, dark, and dry place (Whiting D. et al. 2014).

In conclusion, the shallot has a large market presence as well as a bold and flavorful presence in our meals. With the shallot having a \$3.7B dollar world market and containing the wonderful flavors of both onion and garlic, it makes the vegetable more appealing on a day-to-day basis. Whether adding this vegetable to French onion dip (non-traditional), or growing it for production, the shallot is a well-rounded and hardy vegetable to enjoy every day.

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Fungal Diseases of Tomato

By Jake Silbar

Based on the topics discussed within the Production of Vegetable Crops class, I have identified an exciting and relevant production topic within the agriculture industry. Plant pathogens need more research and growers need more options to address them. There are a number of methods to help prevent and/or control known pathogens, before a plant disease develops. This fact sheet will provide useful information regarding the methods and procedures to fight a specific pathogenic plant disease, partnered with background on a specific vegetable crop affected, the tomato. Figure 2, illustrates the effect of *Pythium* pathogens on a tomato crop (Zitter, 2016). Figure 1, provides a reference for what a healthy, non-affected crop appears to look like (Kemper, 2012).



Figure 1: Healthy green tomato crop (Kemper, 2012)



Figure 2: *Pythium* affected green tomato crop (T.A. Zitter, 2006)

Solanum lycopersicum, commonly known as the tomato, is consumed across the world, with China consuming 54,888 thousand tons and the United States consuming 14,736 thousand tons annually (Avramenko, 2018). An 1893 ruling by the US Supreme classifies tomatoes as a vegetable rather than a fruit. This omits the technical botanical meaning, based on the way tomatoes are consumed. Tomatoes are a bright eye-catching crop that assists in the fight against heart disease, diabetes, and some forms cancer, making this crop an interesting topic to discuss and analyze (Fuhrman, 2018). However, domestication and continued large-scale cultivation may present unintended complications, including a lack in genetic diversity, possibly leading to a more disease-susceptible cultivar.

Tomatoes originate within the Americas, tracing back to the early Aztecs around 700 A.D (Encyclopedia Britannica, 2018). They are a member of the nightshade family, based on the production of an alkaloid compound called solanine. Tomatoes have proven to be utilized in all aspects of the dinner table within the majority of countries around the world. Based on the cultivar and use tomatoes have as fresh produce, coupled with a high percentage of the world's processing industry, this cash-crop has significant economic importance. According to the United States Department of Agriculture, "fresh and processed tomatoes account for more than \$2 billion in annual farm cash receipts (Minor & Bond, 2016). Although there are more than "15,000 cultivars known," according to the Gary Ibsen from Heirloom Tomato Plants, the average consumer observes and purchases a tomato with a red and rounded characteristic (Bauchet & Causse, 2018).

As the domestication of tomato crops has already occurred, both morphological and physiological traits are distinguished between currently consumed tomato crops and their ancestors. According to Helop-Harrison in 2007, the continued selection process of tomatoes

reduces genetic diversity. The common grocery store tomato plant would not survive without the aid of human interaction. Based on the presented limitations and conflicts, management and eradication of diseases may be increasingly difficult to control. According to Dr. Rebecca A. Melanson (2018) there are a number of pathogens that may lead to an unmarketable tomato crop. Looking specifically at fungal infections within tomatoes, unwanted pathogens may present themselves based on specific environmental factors and evidence, which manageable and preventable.

Moore et al. (2018) indicates microbial diseases account for 16% of agriculture crops lost, with 70-80 percent of these losses caused by fungi. *Pythium* pathogens are an example of a causal agent posing damage to cultivated crops. Also being an oomycete, *Pythium* is said to be fungi-like, but not considered a true fungi. This *Pythium* pathogen may be difficult to control, based on limited knowledge and availability of management options. However, management of this plant pathogen is important, as a significant number of crops produced for consumption are diminished from fungal and *Pythium*-related pathogens.

Management strategies, including minimizing the ideal environmental conditions for the pathogen to thrive in, can be a useful preventative measure. Commonly, *Pythium* pathogens are known to develop in over-watered soils coupled with a warm environment. Overall, focusing on the soil structure itself may allow for a better chance to reduce disease outbreaks. Being an oomycete, *Pythium* pathogens cannot be managed with the typical use of fungicides (Melanson, 2018). Assuming one applies a direct fungicide to the infected crops with symptoms ceasing to reside, odds are the causal agent is within the *Pythium* genus. Allowing the soil media time to dry between watering can aid in the prevention of *Pythium* diseases before symptoms arise. Further

observing the soil itself, a well-draining media can allow for periods of drying in between watering, limiting the development of the *Pythium* plant disease.

Soil amendments such as pumice and lava rock help improve drainage, limiting the development of *Pythium*. Based on this, eradication and practices used must eliminate the pathogen by focusing on the soil, not the aerial spores themselves as *Pythium* overwinters in the soil. According to the Department of Environmental Conservation (2015), New York state has utilized metalaxyl or mefenoxam within the treatment of seeds, showing less development of pathogens like *Pythium*. Metalaxyl is a benzenoid fungicide that is commonly used as a foliar spray for tropical and subtropical crops.

Accounting for approximately 401,50 acres of United States land in 2008 and 433,500 acres in 2009, the demand for tomatoes is growing (USDA, 2010). Based on the significant economic importance this cash-crop has, management of damaging *Pythium* pathogens remains valuable. Associated with a number of health benefits, the continued development in plant pathogen management strategies will significantly limit. The number of affected tomato crops. Less pathogen affected crops will not only increase the amount of tomato crops available within the marketplace, but decrease profit loss in those cultivating the crop as well. Overall, minimizing ideal environmental conditions, development of soil structure, and seed treatment practices can significantly limit the number of diseased tomato crops observed.

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Give Me Wasabi, Not Dyed Horseradish!

By Paul Skillin



Figure 1: Sketch of a wasabi plant first published in an 1828 botanical encyclopedia by Iwasaki Kanen (Mitsukuni and Tsune, 1989)

Most people who have been to a Japanese restaurant believe they know wasabi's identity. Many of these people are wrong. What has been passed off to most westerners as wasabi, which may be seen as the condiment on the corner of a sushi dish, is actually dyed green horseradish with a little mustard extract thrown in for flavor. Real wasabi (*Wasabia japonica*, also referenced as *Eutrema japonicum*, Figure 1) is notoriously difficult to grow. This characteristic has, until quite recently, isolated the vegetable to growing in shaded riverbeds in Japan where it has been cultivated since at least the 8th century (Kinjirushi, 2001). Horticultural wasabi is

cultivated all over the world, but its distinct growth habit limits its range. This likely explains its price of \$140/lb (Gittleson, 2014).

Wasabi is a member of Brassicaceae, which includes mustard, broccoli, cabbage, and horseradish. It is grated (customarily on a shark skin covered board known as an oroshi) into a pale green paste (Figure 2). A small amount of wasabi is traditionally placed between the fish and rice in sushi or is placed on the corner of the plate for individualized use by the patron. Wasabi, like

horseradish and mustard, has a notable pungent aroma and spicy taste. However, unlike dyed green horseradish ‘wasabi,’ real wasabi’s powerful flavor quickly dissipates to leave more of a sweet finish.



Figure 2: Wasabi rhizome prepared by oroshi, with resulting paste displayed on a wasabi leaf (Norikko, 2017)

Wasabi is a cool weather vegetable crop which can be found growing in nature in riverbeds in Japan. Since it naturally grows in flowing water, the best wasabi crops are grown under similar conditions. Wasabi grown in modified riverbeds or fields which have water running over them is known as sawa (Figure 3) (Arnaud, 2010). Wasabi grown without a constant flow of water is known as oka. These plants will not grow as large nor be as high of quality as the plants grown by the sawa method. There are around 20 cultivars grow in Japan, each cultivar grown in a specific region and each of which may vary in growth habit, size, leaf and rhizome shape, color, and

tolerance to temperature as well as disease. The two most common cultivars found outside of Japan are known as ‘Daruma’ and ‘Mazuma.’ Wasabi can be propagated vegetatively, through tissue culture or by seed. Wasabi grows best under heavy shade with an air temperature of 43 to 68°F. Wasabi should be grown in flowing water which is highly oxygenated, with a pH of 6.0-7.0, and a temperature of 54 to 59°F. After around 16 to 20 months, the wasabi crop is ready to be harvested. During harvest, the whole plant is pulled out of the river rock in which it was grown,

any plantlets are removed for future propagation or otherwise discarded, and the leaves and roots are removed to expose a rhizome, about 2-4 inches in diameter and 6-12 inches long. This rhizome is washed and sold wholesale or directly to consumers. If kept in a cool and moist environment, it may stay viable for several weeks (Miles and Chadwick, 2008).



Figure 3: Wasabi growing at Daiō Wasabi Farm in the sawa style (Hachi888, 2018)

As is the case with many crops, there are many potential pests associated with growing wasabi.

Wasabi is vulnerable to diseases that affect the Brassicaceae. The semi-aquatic nature of the crop reduces the number of treatment options compared to terrestrially grown vegetable crops.

The semi-aquatic nature of the crop also severely limits the options for fertilization. Foliar pests include aphids, alfalfa loopers, cabbageworm, diamond back moths, crane flies, and slugs. Bacterial diseases include internal black rot syndrome and vascular wilt. Fungal diseases include white rust, downy mildew, damping off, white mold, club root, and, most destructively, black leg. Black leg is considered the most destructive of these diseases due to the way that it causes necrosis through the plants entire vascular system, while at the same time infecting nearby plants through lesions. Fortunately, ‘Daruma’ tends to be resistant to soft rot and black leg, though the other more widely distributed cultivar ‘Mazuma’ is not. Overall, weeds tend to be less of an issue for wasabi because of the semi-aquatic growth requirements of the plant.

Once harvested, options for consuming wasabi other than as a condiment for sushi include wasabi beer, wasabi juice, wasabi ice cream, and even wasabi KitKats (Daub, 2014). In more

mainstream roles, it may be found in soba (buckwheat noodles) or as a condiment for steak. Since the leaves of wasabi are also edible, picking these less expensive plant parts make for a good side dish or as salad greens. Cooking with wasabi is tricky because the allyl isothiocyanates in wasabi that give it a distinctive ‘kick’ will break down in as little as 15 minutes once the rhizome is grated.

The allyl isothiocyanates are also being currently investigated for potentially wide-ranging health benefits. Historically, the reason why wasabi was placed under fish for sushi was to help ward off bacteria which may have been starting to grow on the raw fish (Lu et al., 2016). There are also many anecdotal accounts of wasabi aiding in digestion, helping with weight loss, and even combating heart disease and cancer. Scientific research performed in the past couple of years has indicated that there is at least some truth to these claims. Studies have been done using wasabi on the bacterium *Escherichia coli* and *Staphylococcus aureus* indicating that wasabi does have antibacterial properties (Lu et al., 2016). Mochida and Ogawa (2008) indicate that wasabi has antiviral properties based on influenza viral research. Research has concluded that there is some level of antifungal activity found in some cultivars of wasabi which could possibly help treat other members of the Brassicaceae also affected by those fungi (Pedras and Sorensen, 1998). Weil et al. (2005) demonstrate that wasabi has anti-cancer properties in colon, lung, and stomach cancers. In addition, wasabi may help combat the formation of certain carcinogens which have raised health concerns as well (Shimamura et al., 2017). Furthermore, research indicates wasabi may help to prevent obesity and insulin resistance, even from parts of the plant that are generally considered unusable (Ogawa et al., 2010).

Wasabi’s high labor inputs and extremely specific environmental condition requirements such as flowing water and constantly cool yet not freezing temperatures make it a high value vegetable crop. Unfortunately, not all consumers are willing or able to afford to purchase authentic

wasabi at the \$140/lb retail rate. Because of this, the subtle spicy to sweet alternating flavor of wasabi goes unappreciated. Likewise, the medicinal benefits associated with the crop such as its ability to ward off infection, lower the risk of diabetes and fight cancer are not utilized. A possible approach to expand wasabi cultivation might be to expand the scale of operation of wasabi farming in areas such as the Pacific Northwest which naturally fit the growth requirements of the crop. This would allow more consumers the opportunity to experience its superb flavor and medicinal benefits. Updated production systems may help to increase yield, so that dyed horseradish can be replaced with wasabi, which would be economically profitable and culinarily valuable.

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Hunger for Cucumber

Samuel Strother

Vegetables are the lifelines that keeping humanity going, and very few of these vital players in the ecosystem tend to be as cool as the cucumber. The sheer euphoria and hydration that a well-groomed and harvested cucumber can deliver is like that of no other vegetable or fruit. To understand this vegetable first people must realize that it is not a fruit or vegetable in actuality it is both, because it comes from the flower and contains the seed, many of vegetables fall under this category. Before I tell you all the different traits and ways to go about growing the plant, let me first tell you about its history. Cucumber was found in India between the Himalayas and the Bay of Bengal, continued in China in the 2nd century. (Wolfard) French explorers found an abundance of cucumber grown by Indians in what is now Montreal around 1535. Cucumber is a member of the Cucurbits family and its name is from comes from the Latin name 'cucumis'.

(Wolfard)

Here's a picture from Google images of an healthy cucumber plant at a mature stage or at least



Fig 1

what we consider a mature state from their lifecycle of being eaten.

When one is planting cucumbers he or she can use transplants or the direct seeding method. Be sure that the chance of frost has passed and you should let the soil warm up due to the fact that it is a warm season crop. The cucumbers seed will have an extremely tough time if the soil is in a cooler temperature range 50 °F so spring and fall crops.

When planting the seeds keep in mind the spacing is crucial compared to certain cultivars, trellised cucumbers should be spaced three feet apart in rows and plant four seeds per foot in the rows.

When they are non-trellised cucumbers space plants about eight inches apart in rows spacing five feet in between each. (Smith, 2003)

Cucumbers are different in the way that they are commonly consumed in two ways primarily, which makes up two groups they are categorized in. The two groups are pickling and slicing, as the name hints at, the pickling cucumbers are used to make the pickles but can be eaten as is also. (Smith, 2003) The cucumbers in this group typically are shorter and have bumps on the skin, grow better in the hotter part of the season. (Smith, 2003)



Fig 2

Figure 2 shows a pickling cucumber being grown; you can clearly see the shape difference compared to a normally grown cucumber. Which would be the slicing cucumber and this is the one you see at the super market with traits such as smooth dark thicker skin, and being considerably longer than pickling.

When the plant matures it will produce vigorous vines shaded by larger leaves. The cucumber plant will grow fast and could potentially have a large yield around two hundred bushels each time if done correctly (Hazinga, 2000). The Old Farmer's Almanac states "in warm summer soil, cucumbers will grow quickly and ripen in about six weeks" Therefore succession planting should be an option (Hazinga, 2000). When you are making pickles it is suggested to prepare them within a day after harvesting them.

Cucumbers are very susceptible to frost damage and must be in warmer soil for germination, with a pH of 6.0-7.0 (Hazinga, 2000). If you are in a cooler climate one can use

alternatives to warm the soil like covering the ground with black plastic to retain more sun and heat energy for the plant. Cucumbers will climb a trellis, which would be the right setup for someone with help limited amount of space for this crop. This will provide more space, help fight off unwanted insects and reduce disease, pressure, overall making harvesting easier. (Smith, 2003) Another way you can fight pest issues is when the ground is warm, mulch with pine straw and chopped leaves, organic mulch to keep them off the ground and avoid disease, this will also help with moisture containment and reduces weeds severely. (Hazinga, 2000)

When caring for the cucumber plant water is the main thing you have to maintain consistent water for this plant to prosper, up to one inch per week if your temperatures are moderate. Drip irrigation is suggested due to the bigger leaves and the concern for leaf disease if dampened regularly. If you find yourself in a situation with a pest problem while planting then use netting to keep them from digging out the seeds. (Hazinga, 2000)

The cucumber is a very versatile plant as explained so far but another interesting fact is that they can be grown to be about any shape or size using bottles and other shape shifting techniques when they are immature you can put it in any shape frame and it will grow in it for example an heart cucumber for holidays. Cucumbers should be ready to harvest and be stored within 50-70 days after emergence, picking frequently to neglect any oversized fruits that is not wanted.

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Bokashi Composting

By Ryley Zeller

Bokashi means “fermented organic matter,” a practice in which food scraps and other sources of organic matter are broken down by bacteria in somewhat of an anaerobic environment.

Bokashi can be purchased in the form of an inoculated grain, the grain is then dried and sold to start what is known as a Bokashi bucket. The inactive bacteria is added to a bucket full of material ready to be composted, molasses, and warm water to “activate” the bacteria responsible for fermentation (Composting Guru, 2018).

During the process, every other day, the leachate that develops should be drained from the bucket. This concentrated byproduct is quite acidic, and people claimed to use it to clean drains, but others have also claimed to dilute it and use it as a fertilizer because of its nutrient density. Although these processes will not be studied in this trial, it is important to be aware of the potential uses of these alternative products.

The result of the Bokashi bucket is a acidic pre-compost and this is typically added to a compost pile. The acidity doesn't seem to have a negative affect on any worms if one is using vermicompost, but if there is concern about the pH of a vermicompost pile the Bokashi pre-compost can be amended with soil and allowed to let sit for about two weeks. This process not only helps bolster the content of indigenous microorganisms but breaks down organic matter in a few weeks instead of a few months (Reddy, 2015).

For this trial, I will be comparing a control bucket that is not inoculated to a bucket with the inoculant. All inputs used in these trials will have been USDA certified organic for the sake of showing the reality of using this system on a larger scale. The organic matter being composted was not differentiated in this way because it will not be used in the growth of the vegetable plots. The steps taken to be able to start the Bokashi bucket will be explained, but the buckets in the trails did not finish completely, so the data is not sufficient to support the hypothesis that the inoculated bucket will decompose the organic mater faster than the bucket that is not inoculated (Reddy, 2015).

The bacteria can be collected by washing rice and straining the carbohydrate dense wash into a ball jar. The ball jar is then set out with the lid loosely fixed on the top, and within a few days bacteria will collect. The lactic acid bacteria (LAB) is isolated by decanting the the excess water from the ball jar and filling it back up with milk. This isolates lactic acid bacteria because unique lactose dense environment it can tolerate.



Collected LAB before milk is added.

Once the milk and LAB has fermented for about a week it will separate out into curd and what is left in the liquid layer will be isolated lactic acid bacteria. This can be diluted in unchlorinated water and used as a root drench to promote healthy fauna, support the indigenous microorganism population, and keep bacterial and fungal diseases

from spreading. It will be used to help decompose organic matter in a enclosed system for



convince sake (Ikeda, 2013). In this trial, the control started to have visible mold cultures around the third week of storage. About three weeks after this the odor is quite obvious and the material would have most likely been composted in a normal outdoor system by now. The research done indicates that the inoculated organic matter would be decomposed and ready for its intended use within two weeks, and ready to be incorporated into soil in another two (Ikeda, 2013).

Control after five weeks.

The benefit to using Bokashi buckets is that it is faster than normal composting, can be done in a sealed bucket, has very minimal smell, and can be stored until it is ready to be used. Over the winter, smaller farms or community gardens can supplement their garden by storing Bokashi compost throughout the winter and applying it in their composting just before the grow season. This will provide the growers with a nutrient dense starting soil that will help to congregare and bolster microorganism populations as well as increase the plants vigor during emergence and help support the plants immune system overall (Composting Guru, 2018).

This process is by no means necessary but can prove useful in more than just small scale vegetable production. These systems could be used in lager scale farming but the conventional standards for farming would not allow it. Meaning the idea that a farmer would grow just corn and use the Bokashi method, and other natural farming methods, is impractical. If that farmer

was to reduce his density of corn and incorporate other food crops, and horticultural crops that may be beneficial in other parts of the growing system, the farmer could become more self sustainable, have less of an ecological impact, and ideally not fluctuate much in profits.

The incorporation of these systems into farming practices could prove to be a good introduction to more natural farming methods. Farmers may use some of these practices without knowing it, but can still be quite resentful of terms like “natural farming.” This is unfortunate because it can have many practical applications in commercial farming if the conventional concepts of farming were looked at in a different light. Although this is mostly objective, there have been growers that have started companies with these practices in mind. A future when these practices could be predominantly used in commercial systems is unclear, but there is most definitely application in smaller operations. This all starts through education, if these ideas and methods can become more commonplace and better understood by the community as a whole, they can become more practical. The more practical it is to grow good nutrient rich food, the easier it is to be aware of our health and what we are eating on a regular basis.

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