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An Evaluation of Eight Pumpkin Varieties in Central Virginia

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Abstract

Pumpkin production is on the rise in Virginia. Pumpkins make up 8.4% of the total market value of all vegetables sold in the state and acres in production of pumpkins increased by 5.2% from 2007 to 2012. Types of pumpkin production methods, insect, disease, and weed management, pollination, and harvest and post-harvest management all must be considered by pumpkin producers. Unfortunately, pumpkin cultivar performance in the Mid-Atlantic is not well documented. Thus, a variety study was performed using eight different pumpkin varieties over the 2017 and 2018 growing seasons. The study took place at JETT Farms, Inc., located in Madison County in the Central Virginia area. At harvest, pumpkins were counted and weighed, and then an average and total fruit weight was calculated for each cultivar.

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Introduction

Pumpkin production in the state of Virginia is on the rise. With 2,500 acres of pumpkins planted just in 2017, and with an estimated 22,500 pounds per acre harvested, and each pound being worth approximately \$.144, that gives an estimated total of \$7,760,000 in production value for the state of Virginia (Ellison, 2018). This means that pumpkins make up 8.4% of the total market value of all vegetables sold in the state (Ellison, 2018). According to the 2012 and 2007 US Agriculture Census, the number of farms growing pumpkins decreased by 13%, but from 2007 to 2012 the total number of acres in pumpkin production increased by 5.2% (USDA-NASS, 2014). Agritourism is also on the rise in the state, which could be a large contributor to pumpkin production growth and why pumpkin production is important in the state. Consumers visit farms as a way to connect with agriculture and as a way to have an agricultural experience. Pumpkins can give a “nostalgic” feeling for the general public who have no knowledge of agriculture production and farming (Stoller-Conrad, 2012). The Economic and Fiscal Impacts of Agritourism in Virginia stated that “more than one third of agritourism establishments in Virginia have been in operation for five years or less which is a testament to the recent growth of the sector” (Magnini, 2017).

In Virginia, pumpkins are normally grown and marketed for ornamental use- very few pumpkins in the state go on to be processed. The intended market will dictate planting date and cultivars that are to be planted- pumpkins needed for wholesalers must be ready much earlier than pumpkins that will be sold directly to the consumer. Depending on the sales outlet, a grower may need to have ripe pumpkins available for sale from the end of August through mid-November (Bratsch, 2009).

Pumpkins can be grown on conventionally, reduced, or no-tilled fields. Good cover crop management is essential in a no-till pumpkin production system. Plasticulture pumpkin production is

gaining in popularity in some areas of the state, especially in areas that are primarily wholesale production.

Diseases on pumpkins also pose a challenge for growers. The most common diseases that growers face are: anthracnose, bacterial wilt, downy mildew, Fusarium fruit rot, Phytophthora crown and fruit rot, plectosporium blight, and powdery mildew. Many seed companies are developing hybrid pumpkin varieties that are showing at least intermediate resistance and/or tolerance to black rot, powdery mildew, Phytophthora crown and fruit rot, and Fusarium wilt (Wyenandt, 2019). Good variety choices and integrated pest management techniques (such as crop rotation, cover crop use, appropriate site selection, following good sanitation practices, and in-field disease scouting) can be incredibly helpful in decreasing the amount of disease pressure in the field and may decrease the amount of chemical fungicides that need to be used.

Weed management within the pumpkin crop can also pose challenges. This is where having a good cover crop stand and management program can be critical. Using pre-plant herbicides can also decrease weed pressure. The most critical piece to decrease weed pressure is establishing a good canopy that can compete with weeds and provide shading to decrease their growth (Bratsch, 2009). Once pumpkins are out of the ground, post emergence weed control options for broadleaf weeds are very limited, but post emergence grass controls are available. The Mid Atlantic Commercial Vegetable Production Recommendations guide (Wyenandt, 2019) lists available herbicides.

To obtain adequate disease and weed control, cultivar selection is paramount. Unfortunately, pumpkin cultivar performance in the Mid-Atlantic is not well documented. Thus, a variety study was performed using eight different pumpkin varieties over the 2017 and 2018 growing seasons. The study took place at JETT Farms, Inc., located in Madison County in the Central Virginia area.

Objectives

The purpose and objectives of this project were to determine if selected varieties would be productive in the Central Virginia area. There were eight different varieties that were evaluated during the growing seasons of 2017 and 2018. At the end of each growing season the number of pumpkins per variety were counted and weighed. Average fruit weights were also calculated.

Literature Review

Pumpkin Production

Historically, pumpkins in Virginia were grown on conventionally tilled soil. Having these conventionally tilled soil beds allowed for a seed bed that was good for pumpkin seed germination. The loose soil structure promoted good seed placement in the ground, and added nutrients could easily be incorporated into the soil for plant use. However, conventional tillage may result in soil erosion, nutrient runoff, soil splash on fruit, decreased quality of pumpkins, and increase the amount of labor and inputs needed to plant a crop (Harrelson et al., 2007).

Due to the increased interest in conservation practices and nutrient management importance, conservation tillage, or no-till systems, have become very popular. Many vegetable crops are not seen as good candidates for no-till systems because of the need to get crops in the ground in the early spring when soil temperatures are still cool. No-till systems often keep the soil cooler for longer in the spring, which may decrease the germination rate of the earlier planted vegetables. Since pumpkins are planted later in the season, giving the soil time to warm up, they are a much better choice for reduced tillage systems. There can also be an increase in nutrient availability due to the breakdown of organic matter from the use of cover crops (Harrelson et al., 2007). The use of cover crops is important in no-till systems. A crop, such as wheat, rye, triticale, or others, is planted in the fall and then killed for use as a ground cover and seed bed for planting. The use of these crops can dramatically increase the amount of

moisture that is retained in the soil, help keep weeds out of the field, and keep fruit dry, increasing the overall marketable percentage of the crop (O'Rourke et al., 2016). No-till and cover crop practices may also decrease the amount of fungicides that are needed in a growing season. Increasing water movement away from the fruit and decreasing the time that the fruit is in contact with the water may decrease pathogen dispersal and splash onto the fruit (Everts, 2002).

Strip tilling practices, or a combination between conventional tillage and no-till, may be an option for some growers who are looking for the conservation benefits of no-till but need more soil bed preparation. However, studies have shown that soil erosion may still be high and weed pressure is still a significant problem in this production method although it is more viable than conventional tillage in managing soil erosion and increasing soil moisture (O'Rourke et al., 2016).

Another option that growers have that is not as commonly used in pumpkin production is plasticulture, or planting in plastic mulches. In this production method, pumpkins are grown on strips of plastic over raised beds and often using drip irrigation in the beds. While this method has a high cost that may not offset the lower value of pumpkins, growers may find advantages to plasticulture that make it a viable option for them, such as: increased yields, earlier maturing crops, higher quality fruit, better insect, weed, and disease management, better weed control, and more control of inputs such as water and nutrients (Lamont, 2017).

Soil testing is essential for pumpkin growers and should ideally be done annually. Lime applications should be made preferably in the fall to allow optimum time for the pH to become more basic if needed as cucurbits prefer a soil pH range of 6.0 to 6.8. Potassium and phosphorus are both very important nutrients for pumpkin production and a soil test should be taken every growing season before pumpkins are planted (Bratsch, 2009). Growers should amend the soil so that phosphorus and potassium levels are both at optimum levels. A total of 150 pounds per acre of P_2O_5 is recommended. If

the soil test indicates low levels, 150 pounds should be added, 100 pounds if the level comes back as medium, 50 pounds if the soil test comes back as high, and no P₂O₅ should be added if the test levels come back as very high. A total of 200 pounds of K₂O is recommended over the growing season. If the soil test levels indicate “low” levels, 200 pounds should be added, “medium” soil test levels would need 150 pounds applied, “high” levels would need 100 pounds applied, and “very high” readings need no supplemental potassium. A total of 50-100 pounds of nitrogen should be applied over two applications during the growing season. 25-50 pounds of nitrogen should be applied at the beginning of the growing season along with any potassium and phosphorus, and then an additional 25-50 pounds should be sidedressed on the plants as the vines begin to run (Wyenandt, 2019). Supplemental nutrient applications of nitrogen, boron, sulfur, and/or magnesium may be needed depending on soil test results. (Bratsch, 2009).

Moisture has a huge impact on pumpkin production. Direct seeded pumpkins can have a root system up to 4 feet long but pumpkins grown in a plasticulture system will have a much shorter root system. If irrigation is used, light waterings should occur when the pumpkins are in a seedling stage, before the root system is fully developed. When the pumpkin plants are older and the root system is larger, the plants can handle longer periods without rainfall, but any irrigation must be much deeper. Using one of several models; whether it be a tensiometer, gypsum block, ceramic sensor, or the water budget method to determine the appropriate amount of water that is needed in the field is essential. Too much water or too little water can stress on the pumpkins that may lead to a decrease in yield. Using any type of mulch, whether it be plastic or residue from a cover crop, can help keep moisture in the soil and available to the plants (McClurg et al., 2003).

Insects

Insects can also pose a threat to pumpkin production. The most common insect found on pumpkins in the Mid-Atlantic region are squash bugs. Squash bugs prefer summer squash and pumpkins as their host plants and cause damage by piercing through the leaf causing disruption to the xylem and causing the plant to wilt, especially if there are large numbers of squash bugs feeding on the leaves. Squash bugs also cause damage to the fruit with their piercing, sucking mouthparts. Not only does it blemish the fruit, they also can lead to the introduction of secondary fungal or bacterial infections because of the initial injury. Growers must be diligent about scouting for these bugs when they are in the egg stage by checking the undersides of the leaves for egg masses. Chemical control was the only option that many growers used for control; however, egg parasitism by different flies and wasps has been shown to control the populations as well (Doughty et al., 2016).

Cucumber beetles can also be an insect of concern in pumpkin production, especially with young plants just out the ground because of the threat of bacterial wilt being spread to the plants from the cucumber beetles. Using seeds that have been treated with a neonicotinoid seed treatment like Farmore DI400 (Syngenta Crop Protection, Greensboro, NC) helps to decrease the impact that the cucumber beetles may have (Wyenandt, 2019).

Proper identification of insects is key to control. Integrated pest management, and using insecticide sprays as a last resort, can be a good option to decrease pesticide usage and insecticide resistance development. Crop rotation to a crop that is a nonhost crop, spot treatment of heavily infested sites or sites where insects may have overwintered, treating insects at an early stage in their life cycle if pesticides are used, and alternating insecticide modes of action if sprays are used is critical (McClurg et al., 2003). It also needs to be understood that a grower should be consistently scouting the fields to

determine the number and types of insects (including beneficial predatory insects) that are present in the field so that a threshold can be identified for spraying to begin.

Pumpkin Diseases

Disease is one of the biggest issues that producers face when growing pumpkins. The three biggest disease challenges for growers are powdery mildew, downy mildew, and *Phytophthora* crown and fruit rot.

Powdery Mildew:

Cucurbit powdery mildew is a fungal disease caused by two main organisms, most commonly *Podosphaera xanthii* and less commonly *Erysiphe cichoracearum* (McClurg et al., 2003). Many cucurbits have cultivars with at least some resistance to the disease. The disease is seen on the leaves, petioles, and stems. The fungus develops first on the crown leaves, then on shaded lower leaves and on leaf undersides. Where there are powdery mildew colonies on the undersides of leaves, often there can be yellow spots on the upper parts of leaves opposite the colonies. The infected leaves normally wither and die, which can then cause premature ripening of the fruit or the fruit may become sunburnt due to lack of protection from the leaves. It can also decrease storability in winter squash, lead to poor flavor in melons, and poor rind color and shriveled handles in pumpkins. The stress on the plant from powdery mildew can lead to more diseases (McGrath, 2017).

It is believed to be airborne from other infected crops- starting in the southern states where cucurbits are grown earlier in the year. The fungus can remain viable for 7-8 days, but cannot survive without some sort of host (McGrath, 2017).

Powdery mildew can develop very quickly under favorable conditions because the length of time between infection and symptoms is usually only 3-7 days. Dense plant growth, low light, low air

movement, high relative humidity, and temperatures of 68°F to 80°F can all lead to very favorable conditions for powdery mildew development. There must be dryness for the fungus to colonize, sporulate, and disperse, and rain and/or moisture on the plants is not favorable for fungus to develop. Temperatures over 100° F stops the development of powdery mildew. Many plants do not become affected until after there is fruit set on the plant (McGrath, 2017). It generally occurs in the crop from mid- July until the end of the growing season (Wyenandt, 2019).

For chemical control, fungicides should be applied every 7-10 days once the fungus is detected on the plants. Plants should be scouted very closely once fruit set begins as that is when the plants are more susceptible. The upper and lower portions of the leaves should be inspected for colonies. With a recommended preventative schedule, spraying should begin when female flowers begin to open or when one lesion is found on the underside of 45 old leaves by scouting (Wyenandt, 2019). For the best control, fungicide sprays need to contact both the underside of leaves and leaves low in the canopy. Higher gallons of water per acre, air assisted sprayers, and smaller droplet size can increase the coverage of fungicide sprays on plants. The label will list specific recommendations of how many gallons per acre of water should be used as well as the recommended PSI to be used in the sprayer (Wyenandt, 2019).

Pumpkins are now being developed and sold by their resistance level to powdery mildew so cultivar selection is a viable option to assist growers in decreasing the amount of powdery mildew that may affect their crop.

Downy Mildew:

Downy mildew is a cucurbit disease caused by the fungal-like oomycete pathogen *Pseudoperonospora cubensis* that moves from the southern United States (where it can overwinter)

northward throughout the growing season. Symptoms may vary depending on how quickly the plants are infected. Upper surfaces of the leaves can show angular pale green areas bounded by leaf veins which then change to yellow spots and become necrotic. In moist environments, sporulation occurs on the lower leaf surface with yellow, necrotic sections on the upper side of the leaf directly above the sporulation. The patches on the undersides of the leaves can appear to be gray and “downy” (Quesada-Ocampo, 2019).

The spores can be wind-borne and can survive over long distances if the air is moist. They are also easily spread to other plants by splashing water. Most of the time downy mildew is considered a cool, wet weather disease, however it can also be spread and infect plants over a 50°F to 80°F degree range. The optimum temperature is 61°F to 72°F. If there is heavy dew in the morning, that can be enough for infection to occur. High humidity, overhead irrigation, or rain can be ideal growing conditions. The pathogen needs a host to survive and it can only overwinter on plants in sites with warm weather, such as the southern US and greenhouses (Quesada-Ocampo, 2019).

Fungicides are required to control downy mildew in pumpkin production and care must be taken to apply fungicides before downy mildew is seen in the field (Wyenandt, 2019). Growers can track the progress of downy mildew by using the Cucurbit Downy Mildew IPM Pipe website (<http://cdm.ipmpipe.org>).

Phytophthora Crown and Fruit Rot:

This is pumpkin disease caused by *Phytophthora capsici* and causes seedling damping-off, leaf spots, foliar blight, root and crown rot, stem lesions, and fruit rot. Leaf spots can be dark brown and large. If it is crown rot, the plant dies in a very short period of time. When the vine is affected, the tissue becomes brown, appears water soaked, and often collapses (McGrath, 2018).

Fruit rot normally starts on the side of the fruit that has contact with the ground. It can start as either a water soaked spot that could have fungal growth in it or it could be a depressed spot in the fruit that are very soft and easily punctured. If the vine is infected, the symptoms can also begin around the stem area. The pathogen produces a white, yeast-like growth, especially under moist conditions (McGrath, 2018).

The pathogen can survive in the soil for more than two years between crops. If oospores are produced, the fungus can last even longer in the soil. For the disease to occur, there must be adequate soil moisture and soil temperature above 65°F (McGrath, 2018).

Growers can use some cultural control methods to decrease incidence of Phytophthora in their fields. They can attempt to use fields where Phytophthora has never occurred before, observe at least a 3-year crop rotation, use well-drained fields, and separate plantings of susceptible crops. The pumpkin varieties with a harder rind may be less susceptible to the Phytophthora fruit rot. Good field practices such as cleaning equipment between infected fields, wearing clean clothes and shoes between fields if there are multiple crops that may have an outbreak, and being careful with irrigation practices can also decrease the likelihood of infection. (Wyenandt, 2019).

Disease Resistance

Growers are having to deal with fungicide resistance development. Common fungicides that growers have used for years are not as effective as they used to be. Fungicide use in pumpkin production is essential because diseases like powdery and downy mildew can cause severe crop losses due to a decrease in photosynthesis in the plant. Overuse of one fungicide can lead to resistant strains of that pathogen, such as powdery mildew populations resistant to benzimidazole carbamates and quinone outside inhibitors (Barickman et. al., 2017).

Good integrated pest management practices and cultural controls that the farmer can use are essential in preventing disease resistance. Crop rotations of at least three years between pumpkin or cucurbit plantings are ideal, using well drained fields, cleaning shoes and clothes between fields if the grower knows that there is a current disease outbreak on the farm, not using overhead irrigation, not irrigating at night, removing infected fruit from the field, and using varieties that have some known disease resistance are all essential in preventing fungicide resistance in diseases ((Barickman et. al., 2017). Using cover crops and no-till production methods can also decrease disease pressure within a field, and therefore disease resistance. A study in Maryland showed pumpkins planted into a cover crop of hairy vetch and hairy vetch plus rye had reduced *Plectosporium* blight severity, decreased the number of fruit with black rot symptoms, and a decrease in powdery mildew severity when compared with pumpkins on a conventional tillage and bare ground production system (Everts, 2002).

Biofungicides may be an option, but the efficacy of these fungicides still needs to be evaluated (Barickman et. al., 2017).

Pollination

Pollinators are an essential component of pumpkin production. As pumpkins produce both male and female flowers, pollen has to travel from a male flower to a female flower to produce pumpkin fruits. Plants normally produce male flowers first with female flowers developing as the plants get bigger. Hot weather can also have an impact on flower production, as during hot weather, or days hotter than 90°F and nights hotter than 70°F, female flowers are not produced by the plant. Appropriate nutrient levels are also essential, as high levels of nitrogen or over-crowding of plants can also lead to a decrease in female flower production. Flowers normally open at dawn and close by late morning, so any pollination that happens must occur during that time frame as the flowers do not re-open (Wien, 2003).

Honeybees have been the traditional preferred pollinator, but bumblebees and squash bees are rising in popularity. Honeybees have some negative aspects that can make them challenging for some pumpkin producers. The bees can sting if disturbed, takes someone experienced to manage them, and they have to be managed so that they will stay on the pumpkin flowers. Squash bees are becoming a more preferred pollinator because they are often native and prefer cucurbit plants. They also will arrive in the field and begin pollinating in the morning before honeybees. Squash bees are nonaggressive and males are unable to sting. For fields that have less than 10 acres of pumpkins, normally the native honeybees and squash bees are adequate for pollination. However, if pumpkins are planted in a field where they have never been before, or if there are more than 10 acres of pumpkins, producers may want to consider supplemental pollinators to help ensure pollination will occur (Wein, 20013.)

Harvest and Post-Harvest Considerations

Producing a high quality pumpkin plant that has been grown under the correct conditions as described above is essential in producing high quality pumpkin fruits that can be sold to the public. Healthy plants that are relatively disease free with little insect damage will more than likely lead to fruit that will be attractive to the consumer and will hold well in storage. The pumpkin's quality will not improve after harvest so a high-quality fruit at harvest is important. The majority of varieties will reach a harvest point approximately 45 days after the initial fruit set. Growers should know the characteristics of the pumpkins that they grow as they cannot rely on fruit color to determine ripeness. Some varieties will be very dark orange when they are ripe while others may be a lighter orange (Riggs et al., 2003).

Pumpkins should be harvested while the stem is still green and before frost. If the stem has started to shrivel and turn brown, more than likely that plant has been infected with some type of disease and the quality of the fruit will be affected. If possible, fruit should be removed from the field soon after harvest as fruit left in the field is more likely to become diseased. If pumpkins are stored, they should be

left in a dry, covered area with 50%-70% relative humidity. It is very important that only pumpkins without disease are harvested and placed into storage bins. If a pumpkin with disease is placed in a bin with other pumpkins, it is very likely that the diseased pumpkin could infect the healthy ones. This would lead to a lower percentage of marketable pumpkins for the grower. The ideal storage temperature for pumpkins is 50°F to 60°F for a long term storage period of up to 6 months. For a shorter time frame in storage, or three to four months, pumpkins can handle a temperature range of 35°F to 70°F (Riggs et al., 2003).

Materials and Methods

Projected Audience:

The targeted audience for this research is pumpkin growers and their advisers. The expected outcome is greater information on pumpkin varieties that are available for growers to choose from.

Research Methodology:

Research took place over two growing seasons in 2017 and 2018. The fields were located at JETT Farms, Inc in Madison, Virginia (38°15'12.9"N, 78°12'38.1"W) on predominately Fauquier silty clay loam with a secondary Meadowville loam soil in USDA Cold Hardiness Zone 7a. In 2017, the pumpkins were planted on June 22 and harvested on September 26. For the 2018 growing season, the pumpkins were planted on June 21 and harvested September 26. More information about the eight varieties that were tested is listed in Table 1.

Table 1. Pumpkin variety, seed source, days to maturity, expected weight range, and noted disease resistance.

Variety	Seed Source	Relative Days to Maturity	Expected Weight Range (pounds)	Disease Resistance
Bellatrix F1	Rupp Seeds, Wauseon, Ohio	95	20-25	Intermediate to powdery mildew
Challenger PMR	Southern States, Richmond, Virginia	100	22-27	Resistant to powdery mildew
Cougar	Holmes Seed, Canton, Ohio	80-85	10-12	Strong resistance to powdery mildew
Cronus F1	Harris Seeds, Rochester, New York	115	25-60	Intermediate to powdery mildew
Kratos F1	Harris Seeds, Rochester, New York	100	20-30	Intermediate to powdery mildew
Magic Wand F1	Harris Seeds, Rochester, New York	115	15-25	Intermediate to powdery mildew
Orange Rave	Rupp Seeds, Wauseon, Ohio	100	15-25	Intermediate to powdery mildew
Superior F1	Holmes Seed, Canton, Ohio	100	20-25	Strong resistance to powdery mildew

In 2017, soil test results indicated that no additional potassium or phosphorus fertilizer was needed preplanting. Fifty pounds of nitrogen was applied after pumpkins germinated and emerged from the ground. In 2018, a fertilizer application of turkey litter was applied on April 15. The litter had an analysis of 40 pounds of nitrogen, 40 pounds of phosphorus, and 30 pounds of potassium. Thirty pounds of nitrogen was applied after pumpkins had emerged out of the ground.

The trials were arranged in a randomized complete block design with four replications of each variety. Each plot was 50 feet long and rows were 8 feet apart. Seeds were planted by hand, approximately one seed per 12 inches and approximately 2 inches deep.

A preplant herbicide application of 1.5 pints per acre of fomesafen (Reflex 2SL; Syngenta Crop Protection, Greensboro, NC), 3 pints per acre of paraquat (Solera 3SC; Source Dynamics, LLC, Scottsdale, AZ), and 1.5 pints per acre of metolachlor (Me-Too-Lachlor II 7.8SC; Drexel Chemical Company, Memphis, TN) in 18 gallons of water per acre was applied 10-14 days before planting. Throughout the 2017 growing season, chlorothalonil (Bravo Weather Stik 6SC; Adama, Raleigh, NC) was applied 2 times at a rate of 3.0 pints per acre. Quinoxifen (Quintec 2.08 SC; Dow AgroSciences, Indianapolis, IN) was applied twice at a rate of 6.0 fluid ounces per acre and tank mixed with chlorothalonil applied at a rate of 3.0 pints per acre. In the 2018 growing season, a fungicide application was only made once due to poor field conditions. Fluopicolide (Presidio 4SC; Valent USA, Walnut Creek, CA) was applied at a rate of 4.0 fluid ounces per acre and tank mixed with chlorothalonil at a rate of 3.0 pints per acre.

Pumpkins were cut from the vines on September 22, 2017 and September 21, 2018. Pumpkins were counted and weighed by row on September 26 both years. Any pumpkins that had any orange on them were counted and weighed. Pumpkins that were not close to maturity were left on the vine.

Analysis of variance was performed on all data categories (ARM software, Gylling Data Management, Inc., Brookings, SD) and means separated using Fishers LSD ($p=0.05$).

1.
August
days



Figure
Pumpkin plot
10, 2017, 49
after planting.



Figure 2. Pumpkin harvest, September 26, 2017, a mix of varieties represented.

Results and Discussion

All eight varieties performed consistently among varieties in the trial. There was a significant difference between seasons, as fruit count, total fruit weight, and average fruit weight of pumpkins was much higher in 2017 versus 2018. In 2018, the Northern Piedmont Center, 10.9 miles from the trial site, received 25.2 inches of rain from June 21 until September 26. During this same time period in 2017, the Northern Piedmont Center received 10.27 inches of rain; the 78-year average for the area is 16.03 inches total for the months of June, July, August, and September.

Magic Wand and Orange Rave were in the top three varieties for fruit count during both growing seasons (Table 2). Magic Wand and Orange Rave continued to be in the top three for 2018 for most total weight even during the very wet season (Fig. 3). In average fruit weight in both 2017 and 2018 Challenger PMR and Kratos excelled (Fig. 5).

Over both growing seasons, only 2 varieties met the lowest weight in the advertised weight range (Fig 6.). The advertised weight range for Cougar is 10-12 pounds, and it exceeded this weight in the 2017 growing season with an average weight of 17.705 pounds. The other variety that met the advertised weight was Orange Rave in 2017 with an average weight of 15.01 and an advertised weight range of 15-25 pounds. During the 2018 growing season, no variety in the trial met the lowest weight advertised.

A variety trial was also held in 2018 in western North Carolina where some of the same varieties were tested. These trials had pumpkins grown on black plastic and irrigated on drip with fertigation applied throughout the season. Under these growing conditions, the Magic Wand weight in 2018 was 3.3 pounds heavier, Kratos was 5.49 pounds heavier, and Cronus was 15.06 pounds heavier when compared to the conventionally field grown, non-irrigated pumpkins in 2017 (Schultheis et al., 2018).

Due to the rainfall amounts that were well over the yearly average in 2018, pollination was severely impacted for pumpkin fruit set. With so many rainy days, the pollinators were not able to be effective in the field which decreased fruit set in the field. The abundance of water also meant plants sent energy to increasing vine and vegetative growth and not fruit set. Increased vegetative growth can also increase shading on nearby plants, which therefore reduces the overall female flower production and decreases fruit set (Wien, 2003). There were also fewer overall plants that survived the growing season in 2018 versus 2017. One theory is that there were more diseases within the plants, especially soil borne diseases such as Phytophthora crown rot which has been shown to be more prevalent in soils with a higher moisture content for long periods of time (McClurg, 2003.) Due to the excess moisture and impassable fields in 2018, only one fungicide application could be made which could also have decreased plant health.

Cougar has a distinct advantage and attribute of needing only 80 days to reach maturity. That makes this variety a good option for growers who either need a variety that matures early for wholesale sales or needs a variety that can be planted later but still reach maturity in time. It is more of a yellow-orange color than a true pumpkin orange color.

In 2017, we did note that Superior was more prone to infection by Plectosporium. In 2018, Orange Rave, and Bellatrix seemed to have more Plectosporium and in some cases Bellatrix had growing vines but no fruit on the vine. It should also be noted that while Challenger PMR excelled in many of the areas tested- especially in fruit weight, with some individual pumpkins weighing over thirty pounds, the fruit itself did not have good holding qualities in the field and many rotted shortly after harvest

Table 2. Pumpkin variety, fruit count, total fruit weight, and average fruit weight at harvest for the 2017 and 2018 growing seasons, Madison, Virginia.

Variety	Fruit Count** (2017)	Fruit Count (2018)	Total Fruit Weight (lbs) (2017)	Total Fruit Weight (lbs)(2018)	Average Fruit Weight (lbs) (2017)	Average Fruit Weight (lbs)(2018)
Bellatrix F1	17.50 d*	4.300 a	268.2 a	17.04 a	15.65 a	1.853 a
Challenger PMR	23.30 bcd	2.500 a	414.6 a	12.59 a	17.88 a	3.483 a
Cougar	30.00 ab	2.300 a	426.1 a	9.600 a	17.70 a	2.180 a
Cronus F1	16.80 d	1.000 a	227.6 a	4.195 a	13.44 a	3.318 a
Kratos F1	22.30 cd	2.500 a	388.8 a	9.040 a	17.81 a	2.850 a
Magic Wand F1	31.30 a	6.500 a	405.0 a	24.21 a	13.00 a	2.805 a
Orange Rave	25.50 abc	8.000 a	380.0 a	24.81 a	15.01 a	2.293 a
Superior F1	23.00 bcd	3.000 a	362.4 a	12.51 a	15.87 a	2.653 a

*Values in same column followed by the same letter(s) are not significantly different at P 0.05 according to Fishers least significant difference test.

** Pumpkin count and weight are based only on those fruit that were estimated to be at least 50% orange and undamaged at the time of harvest.

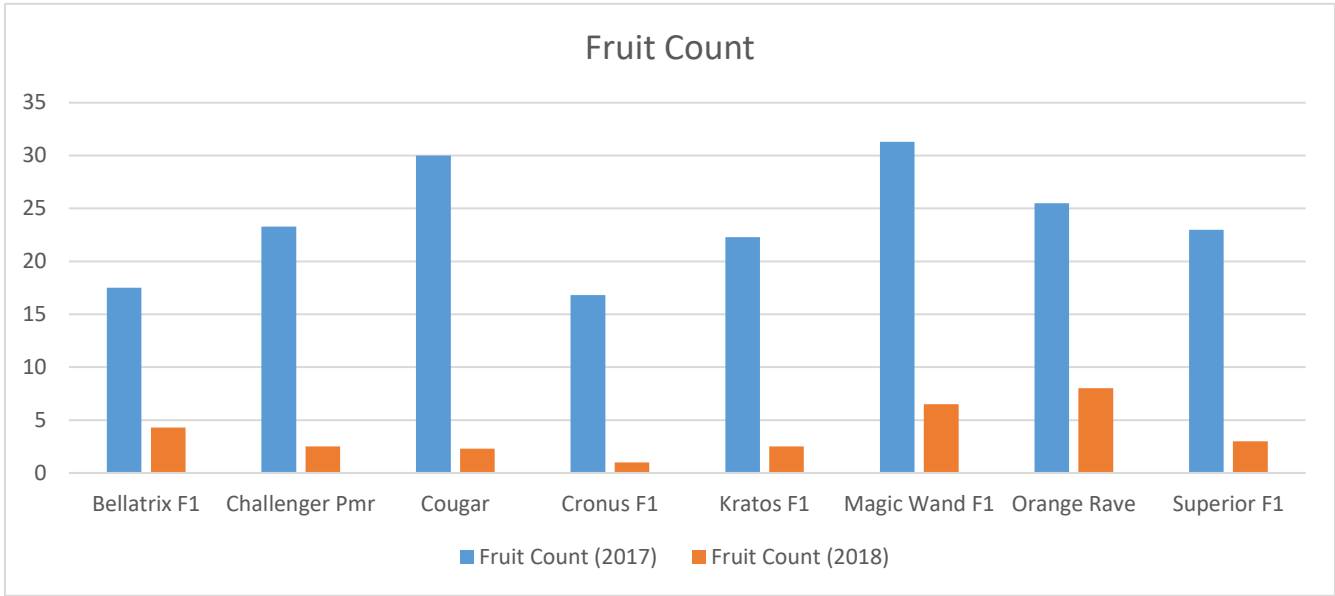


Figure 3. The comparison of total fruit count between varieties in 2017 and 2018, Madison, Virginia.

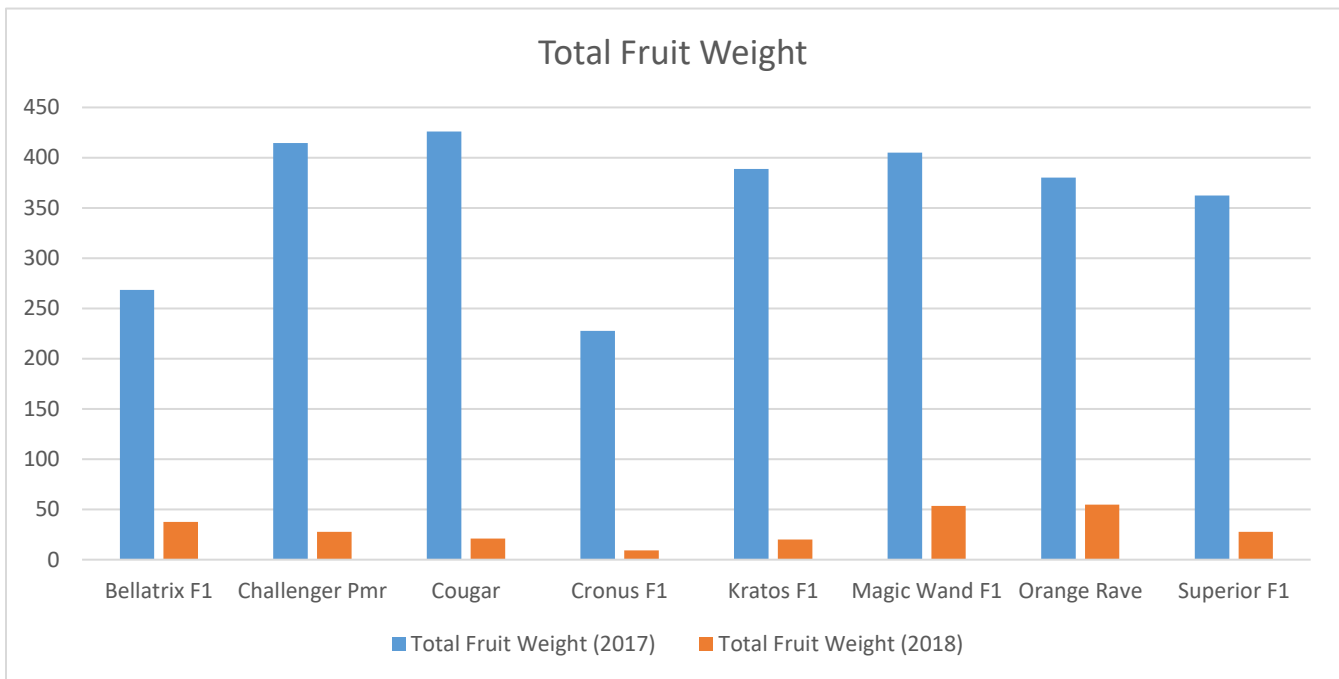


Figure 4. The comparison of total fruit weight between varieties in 2017 and 2018, Madison, Virginia.

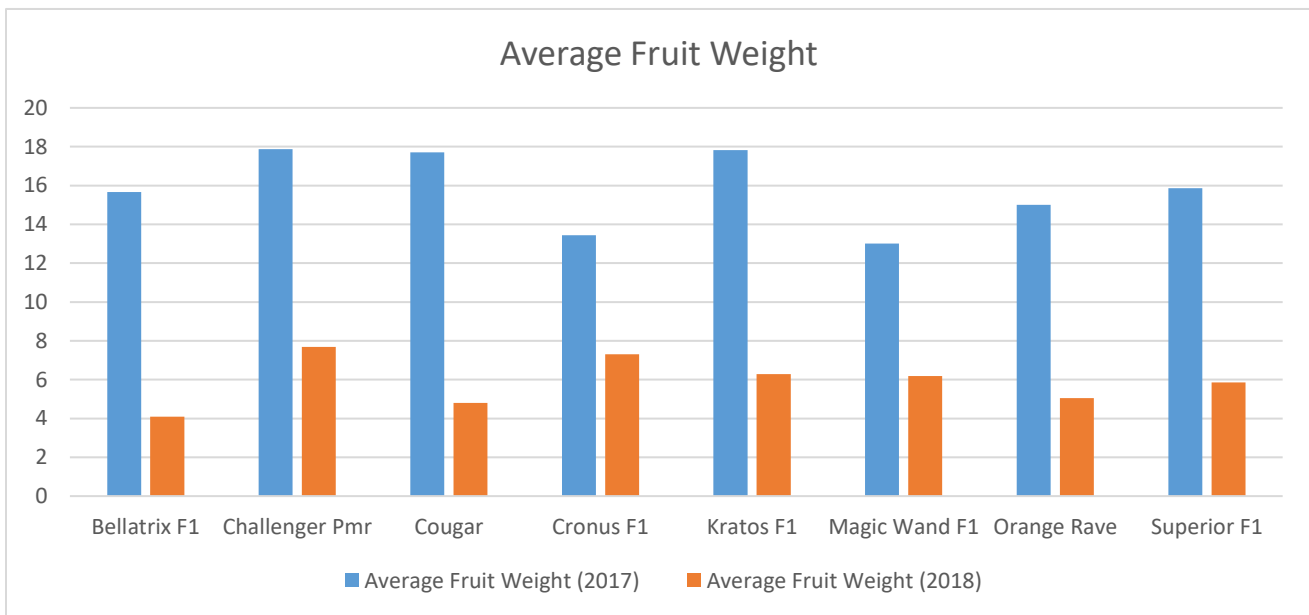


Figure 5. The comparison of average fruit weight between varieties in 2017 and 2018, Madison, Virginia.

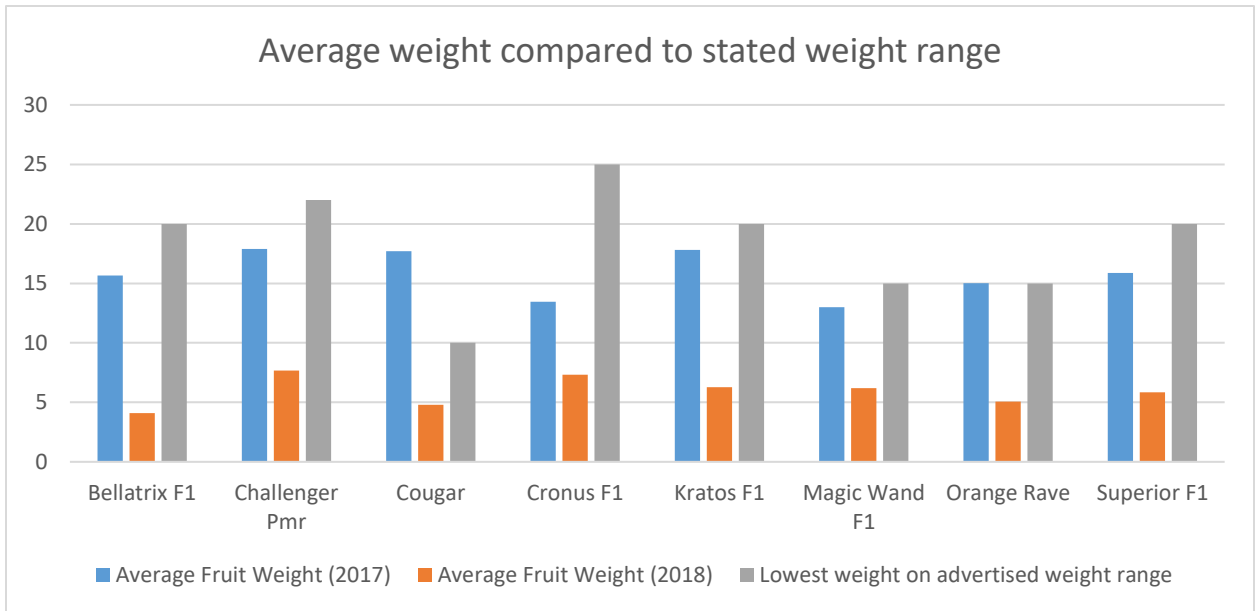


Figure 6. The comparison of average fruit weight to the stated weight as advertised by the seed source, 2017 and 2018 pumpkin trials, Madison, Virginia.

Conclusion

The eight varieties that were tested in this trial are all commonly used, well-known varieties in the Mid-Atlantic region. Magic Wand, while not the heaviest in individual fruit weight, seemed to be one of the more consistent varieties in the trial, producing the highest number of fruit in 2017 and the second highest in 2018, indicating a resiliency in very different weather and growing situations. While Cronus was one of the heavier pumpkins in 2017, it was not a high producer. This was to be expected as we were unable to give Cronus the space that it needs to perform at optimum levels, and should a grower choose to grow Cronus they should make special effort to follow the recommended spacing guidelines between plants. All these pumpkins may be good options for growers who are looking to add proven consistency and variety to their offerings.

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Appendix:

Most Troublesome Pumpkin Diseases in Virginia

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Disease is one of the biggest issues that producers face when growing pumpkins. The three biggest disease challenges for Virginia pumpkin growers are powdery mildew, downy mildew, and *Phytophthora* crown and fruit rot.

Powdery Mildew:

Cucurbit powdery mildew is a fungal disease caused by two main organisms, most commonly *Podosphaera xanthii* and less commonly *Erysiphe cichoracearum* (McClurg et al., 2003). Many commercial pumpkin cultivars have at least some resistance to the disease. The fungal pathogen can infect leaves, petioles, and stems. The fungus develops first on the crown leaves, then on shaded lower leaves and on leaf undersides. Powdery mildew colonies can occur on the upper and lower sides of leaves, often with yellow spots opposite the colonies (figure 1). The infected leaves normally wither and die, which can then cause premature ripening of the fruit or the fruit may become sunburnt due to lack of protection from the leaves. It can also decrease storability in winter squash, lead to poor flavor in melons, and poor rind color and shriveled handles in pumpkins. The stress on the plant from powdery mildew can lead to more diseases (McGrath, 2017).

The fungus is believed to be airborne from other infected crops- starting in the southern states where

cucurbits are grown earlier in the season. The fungus can remain viable for 7-8 days, but cannot survive without some sort of host (McGrath, 2017).

Powdery mildew can develop very quickly under favorable conditions, with the length of time between infection and visible symptoms being as quick as three days. Dense plant growth, low light, low air movement, high relative humidity, and temperatures of 68°F to 80°F favor rapid powdery mildew development. However, there must be dryness for the fungus to colonize, sporulate, and disperse, and excessive rain and/or moisture on the



Figure 1. Cucurbit powdery mildew symptoms and signs. Photo courtesy of Rui map Zheng, Bugwood.org

plants is not favorable for disease development. Temperatures over 100° F can halt the development of powdery mildew. Many plants do not become infected until after there is fruit set on the plant

(McGrath, 2017). In the Mid-Atlantic region, disease generally occurs in the crop from mid- July until the end of the growing season (Wyenandt, 2019).

For chemical control, fungicides should be applied every seven to ten days once the fungus is detected on the plants. However, best control of powdery mildew is achieved by protecting the foliage prior to disease appearance. Plants should be scouted very closely once fruit set begins as that is when the plants are more susceptible. With a recommended preventative schedule, spraying should begin when female flowers begin to open or as soon as symptoms are observed in the field (Wyenandt, 2019). For the best control, fungicide sprays need to contact both the underside of leaves and penetrate the leaf canopy. Increased spray volumes, air assisted sprayers, and smaller droplet size can increase the coverage of fungicide sprays on plants. The fungicide label will list specific recommendations for spray volume and sprayer PSI (Wyenandt, 2019).

Pumpkin varieties are now being developed and sold by their resistance level to powdery mildew, so cultivar selection is the first option to assist growers in decreasing the amount of powdery mildew that may affect their crop.

Downy Mildew:

Downy mildew is a cucurbit disease caused by the fungal-like oomycete pathogen *Pseudoperonospora cubensis*. The pathogen moves from the southern United States (where it can overwinter) northward into our area throughout the growing season. Symptoms may vary depending on how quickly the plants are infected. Upper surfaces of the leaves can show angular pale green areas bounded by leaf veins which then change to yellow spots and become

necrotic (figure 2). In moist environments, sporulation occurs on the lower leaf surface with



Figure 2. Downy mildew symptoms on pumpkin. Photo courtesy of Sarah Sharpe, Virginia Cooperative Extension.

yellow, necrotic sections on the upper side of the leaf directly above the sporulation. The patches on the undersides of the leaves can appear to be gray and “downy” (Quesada-Ocampo, 2019).

The spores can be wind-borne and can survive over long distances if the air is moist. They are also easily spread to other plants by splashing water. Downy mildew is usually considered a cool, wet weather disease; however it can also be spread and infect plants over a 50°F to 80°F degree range. The optimum temperature range for sporulation 61°F to 72°F. If there is heavy dew in the morning, that can



be enough for infection to occur. High relative humidity, overhead irrigation, or persistent rain can

Figure 3. Downy mildew can devastate a pumpkin crop. Photo courtesy of Jason Brock, University of Georgia, Bugwood.org

provide ideal conditions and result in severe damage (figure 3). The pathogen needs a host to survive and it can only overwinter on plants in sites with warm weather, such as the southern US and greenhouses (Quesada-Ocampo, 2019).

Host resistance and other cultural practices are generally ineffective for downy mildew management. Fungicides are required to control downy mildew in pumpkin production and care must be taken to apply fungicides before downy mildew is seen in the field (Wyenandt, 2019). Growers can track the progress of downy mildew by using the Cucurbit Downy Mildew IPM Pipe website (<http://cdm.ipmpipe.org>).

Phytophthora Crown and Fruit Rot:

This multi-symptom pumpkin disease is caused by the oomycete *Phytophthora capsici*. Seedling damping-off, leaf spots, foliar blight, root and crown rot, stem lesions, and fruit rot are among the potential issues. Leaf spots can be dark brown and large. If crowns are infected, the plant can die in a very short period of time. When the vine is affected, the tissue becomes brown, appears water soaked, and often collapses (figure 4) (McGrath, 2018).

Fruit rot normally starts where the fruit has contact with the ground. It can start as either a water soaked spot that could have fungal growth or could be a depressed spot in the fruit that are very soft and easily punctured. If the vine is infected, the symptoms can also begin around the stem area. The pathogen produces a white, yeast-like growth, especially under moist conditions (McGrath, 2018).

The pathogen can survive in the soil for more than two years between crops. If oospores are produced, the fungus can last even longer in the soil. For the disease to occur, there must be adequate soil moisture and soil temperature above 65°F (McGrath, 2018).



Figure 4. Wilted foliage and water soaked leaves are symptoms of *Phytophthora* crown rot. Photo courtesy of Ollie Martin ([CC-BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/))

Growers can utilize cultural control methods to decrease incidence of *Phytophthora* in their fields. They can attempt to use fields where *Phytophthora* has never occurred before, observe at least a 3-year crop rotation, use well-drained fields, and separate plantings of susceptible crops. Pumpkin cultivars with a harder rind may be less susceptible to the *Phytophthora* fruit rot. Good sanitation practices such as cleaning equipment between fields, wearing clean clothes and shoes between fields if there are multiple crops that may have an outbreak, and being careful with irrigation practices can also decrease the likelihood of infection. (Wyenandt, 2019).

Fungicide Resistance:

Unfortunately, for many pathogens, growers have to deal with fungicide resistance development. Common fungicides that growers have used for years are not as effective when used consistently. Fungicide use in pumpkin production is essential because diseases like powdery and downy mildew can cause severe crop losses due to a decrease in photosynthesis in the plant. Overuse of one fungicide can lead to resistant strains of that pathogen, such as powdery mildew populations resistant to benzimidazole carbamates and quinone outside inhibitors (Barickman et. al., 2017).

Good integrated pest management practices and cultural practices are essential in preventing fungicide resistance development. Crop rotations of at least three years between pumpkin or cucurbit plantings are ideal, using well drained fields, cleaning shoes and clothes between fields if the grower knows that there is a current disease outbreak on the farm, not using overhead irrigation, not irrigating at night, removing infected fruit from the field, and using cultivars that have known disease resistance are all essential in preventing fungicide resistance in diseases ((Barickman et. al., 2017).

Using cover crops and no-till production methods can also decrease disease pressure within a field. A study in Maryland showed pumpkins planted into a cover crop of hairy vetch and hairy vetch plus rye had reduced *Plectosporium* blight severity and a decrease in powdery mildew severity when compared with pumpkins on conventional tillage and bare ground production systems (Everts, 2002).

Biofungicides may be an option, particularly for organic producers, but the efficacy of many of these fungicides have not been evaluated (Barickman et. al., 2017).

Choosing a Chemical Control for Pumpkin

Diseases-

Extension recommendations are updated annually according to product registration changes, label changes, and other factors. As a result, specific recommendations and product rates for use on pumpkins are listed in the Mid Atlantic Commercial Vegetable Production Recommendations (Publication 456-420) which can be accessed through your local Virginia Cooperative Extension agent or by visiting www.ext.vt.edu

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