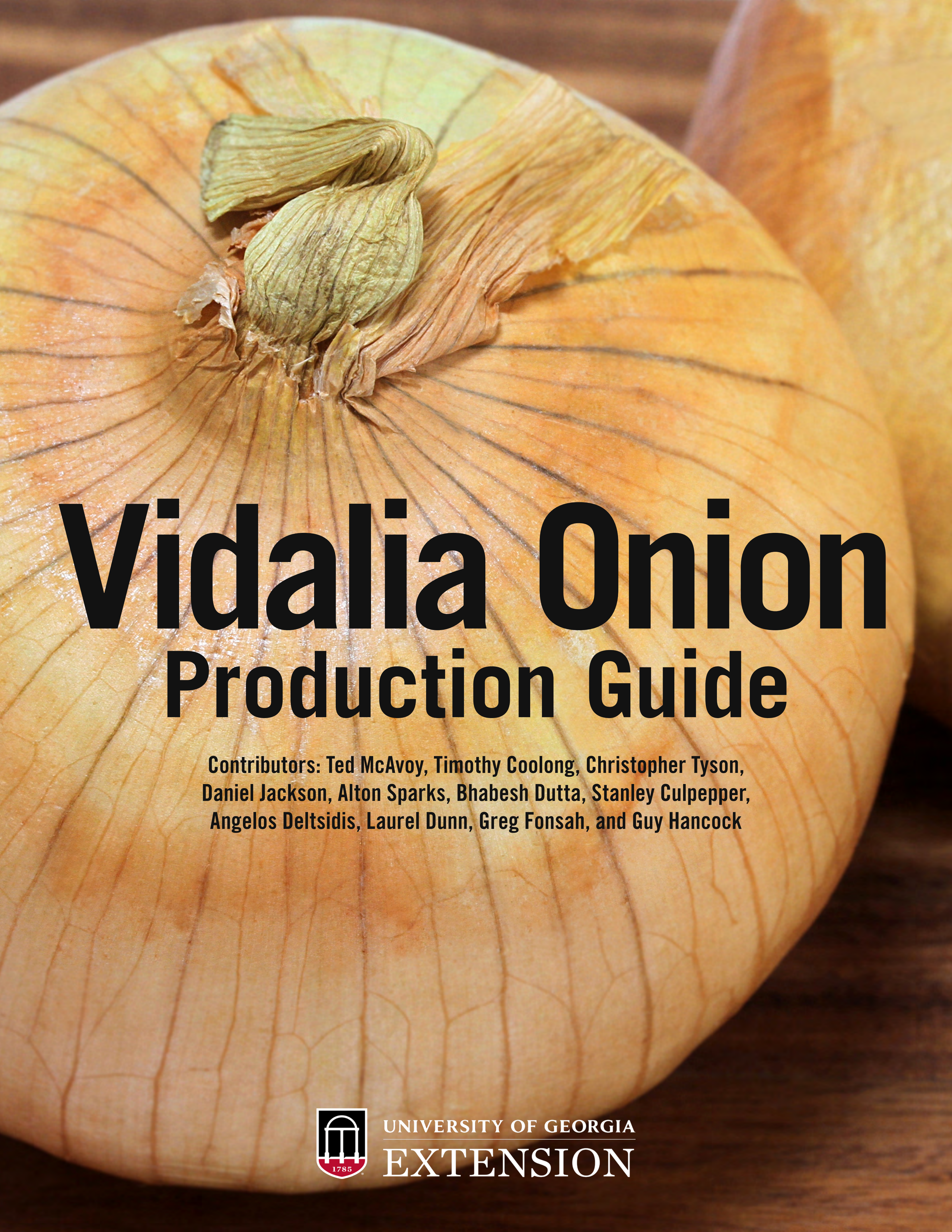

Vidalia Onion
Production Guide

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Contents

Short-Day Onions

Onions are among the most widely adapted vegetable crops, as they can be grown from the tropics to subarctic regions. This adaptation is primarily due to differing responses to day length. Unlike most other species, day length influences bulbing in onions as opposed to flowering. Onions are grouped into three groups based on their response to hours of daylight. The short-day varieties bulb with daylengths of 10–13 hr; intermediate varieties bulb with day lengths of 13–14 hr and are found in the mid-temperate regions of this country. Finally, long-day onions are adapted to the most northern climes of the United States as well as Canada, and they bulb with daylengths greater than 14 hr.

Onions were first brought to this country by early European settlers. These onions were adapted to the temperate climate found throughout the Northeast where the first European settlements occurred. Varieties from warmer regions of the Mediterranean eventually made their way to the Southeastern United States. In particular, varieties from Spain and Italy would become important to the Vidalia onion industry. The first of these varieties came through Bermuda and were thus referred to as Bermuda onions.

'Yellow Granex', the standard for Vidalia onions, has its origin from 'Early Grano'. The variety 'Early Grano 502' resulted in the 'Texas Early Grano 951C', which became one of the parents for 'Yellow Granex' hybrid. The other parent was 'YB986', which was selected from 'Excel', which in turn was derived from 'White Bermuda'. The 'Granex' name is a combination of 'Grano' and 'Excel', the original parents.

The Vidalia onion industry began in 1931 when a grower by the name of Mose Coleman grew the first short-day onions in Toombs County. These mild onions were immediately popular with customers. At the beginning of the depression, these onions sold for $3.50 a 50-lb bag, a considerable amount of money at the time. Soon other growers became interested in these mild onions. The industry grew slowly and steadily for several decades.

Its growth was fueled by the fact that the city of Vidalia sat at the intersection of important roads prior to construction of the interstate highway system. In addition, the supermarket chain Piggly Wiggly maintained a distribution center in Vidalia and would buy the onions and distribute them through their stores. Slowly the industry began to gain a national reputation.

To help promote the onions further, onion festivals were started in both Vidalia and Glennville in the mid-1970s. At this time, approximately 600 acres of onions were produced. Growth continued during the next decade. In 1986, the state of Georgia gave Vidalia onions official recognition and defined the geographic area where these onions could be grown. There had been some problems with onions being brought in from other areas and bagged as Vidalia onions, but the state recognition did not give the industry the national protection it needed. Finally, in 1989, the industry was able to obtain Federal Market Order 955, which gave the industry national protection.

The Vidalia Onion Committee was formed to oversee the federal market order. Growers are required to register and give check-off funds to support the industry. Growers should check the Georgia Department of Agriculture Vidalia onions website (https://www.agr.georgia.gov/vidalia-onions) or call the department for information about growing Vidalia onions. Growers are required to be within the defined growing regions, use specific approved varieties, and register with the state of Georgia.

The collected money from the check-off is used for national and international promotional campaigns, as well as for research on onion production. The adoption of the federal market order has allowed the Vidalia onion industry to grow to its current level of approximately 10,000 acres.

Transplanting and Direct Seeding

Transplant Production

Short-day onions can be grown from both direct seed and transplants; however, most are grown from transplants. Although transplanted onions are more labor intensive, they are preferred to because of better stand establishment and, more importantly, there are better weed control options for transplanted onions compared to direct seeding.

Transplant production begins in late summer with land preparation followed by seed sowing in September. Land for transplant production should not have been in onions or related Alliums for at least 3 years. This is not always possible with fixed center-pivot systems. However, sites with a history of onion diseases and severe weed problems should be avoided.

Transplant Production–Seeding Rate

Once a site has been selected, a soil test should be taken to determine the level of fertility and soil pH. The University of Georgia (UGA) has specific recommendations for plant bed onions. Therefore, when submitting a soil sample to UGA's Soil Test Laboratory, make sure to indicate that it is for transplant (plant bed onion production). The site should be deep turned to bury any residue from the previous crop. Several different seeders are available for transplanting. These should be set to sow 60–70 seeds per linear ft. As an example, using a Plant-It Jr. four-hopper transplanter, set the plates to No. 24. This should give the needed seeding rate for plant beds. Vacuum seeders are also a good choice and can accurately deliver seed in the amounts and to the depth required. Other seeders can be used if they can sow 60–70 seeds per linear foot and can consistently plant the seed at the proper depth (1/4–1/2 in.).

Transplant Production—pH and Nutrient Management

The plant bed soil should have a pH range of 6.0–6.5 for optimum growth. Soils in Georgia are generally acidic; therefore, if your soil pH is low, applications of lime are recommended. Dolomitic lime is preferred over calcitic lime because it supplies both calcium and magnesium while adjusting the pH. Changing soil pH is a relatively slow process; therefore, if low pH is suspected, early soil testing and lime application are advantageous to ensure the soil pH is corrected in time for planting. Soil pH can take several months to change with lime applications.

Nitrogen (N) recommendations on Coastal Plain soils range from 100–130 lb N per acre for seedbeds. On Piedmont, Mountain, and Limestone Valley soils, apply 90–120 lb N per acre. Table 1 describes fertility recommendations for onion plant bed production, including the phosphorus and potassium recommendations based on soil residual phosphorus and potassium levels. Most growers use a complete fertilizer, such as 10-10-10 or 5-10-15, to supply most of their fertility in seedbeds.

In addition, boron should be applied at 1 lb per acre. If zinc results are low, 5 lb per acre of zinc should be applied. Sulfur is critical for proper onion production. This is particularly true on the

Coastal Plain soils of southern Georgia that are very low in sulfur. Sulfur at a rate of 20–40 lb per acre will be required to produce quality onion transplants on these sandy loam soils.

A typical seedbed fertility program would consist of 300–400 lb per acre of 10-10-10 fertilizer with 12% sulfur applied preplant. This would supply 30–40 lb of N-P-K along with 36–48 lb of S. This would be followed by additional applications of P and K according to soil test recommendations. Additional P will generally not be needed, while additional K can be supplied as potassium nitrate (13-0-44). Most growers usually apply around 5–15 lb/N every 10–14 days with applications of 10-10-10 or 5-10-15. This spoon-feeding approach keeps the plants from growing too fast and getting too lush, and it mitigates lodging.

It should be noted that any fertilizer that supplies the required nutrients as required by the soil test can be used to produce plant bed onions. More recent work indicates that high P applications at plant bed seeding have no effect. Phosphorus can have limited availability during periods of cool soil temperature, but bed seeding should be planted in September. At that time, soil temperatures are sufficiently high to avoid P deficiency. Plant beds that have not been fertilized properly at seeding, however, may require 'pop-up' fertilizer to overcome deficiencies during the cooler months of November and December.

It is critically important that seedbeds be irrigated regularly during the first 4–7 days to enhance emergence and develop a good plant stand. A tenth to a sixth of an in. of water applied every day to every other day may be needed to ensure consistent soil moisture during this time. Once seedlings are established and have roots, watering can be limited to 1–2 times per week as needed to ensure adequate soil moisture. See the section on irrigation.

Most growers top their seedling beds with a rotary mower. Most will mow 1–3 times before they pull their onions for transplant. A common practice is to mow them to a height of 7 in. once they reach that height or begin to grow above it. The main reason for this is to keep the plants and leaves from lying on the ground. This keeps air moving through the canopy and prevents moisture from building under the leaves. When growers are ready to pull plants for transplants, they will often mow them at a height of 5–7 in. Many workers use a string to "top off" plants that are taller than 7 in. or have not been mowed within a few days of pulling. Never mow seedlings when they are wet. It is best to mow when it is sunny with clear skies so that the cuttings dry in the seedbeds and do not promote disease. Many growers spray their seedbeds with copper immediately after mowing as well.

Plants are ready for harvest in approximately 8–10 weeks. Good quality transplants will be about the diameter of a pencil when ready. Transplants are pulled and bundled in groups of 50–80 plants and tied with a rubber band. Harvested transplants are transported to the field in polyethylene net or burlap bags. Onion transplants can experience a 'heat' in these bags, which greatly reduces transplant survival. You should never pull and bag plants when they are wet—doing so will increase chances of a "heat" and can cause leaves to rot. Many growers will leave them in bags overnight waiting on them to be planted. Care should be taken with transplants so they are not stored for excessively long periods of time in these bags, nor should they be left in the sun for too long. Planning is critical; harvest only enough plants that can be reasonably transplanted that day. Overnight storage in these bags should be avoided whenever possible, but if it is necessary, they should be removed from the field and moved to a cool dry location. Transplant planting dates are listed in the cultural practices section of this guide.

Direct Seeding

Alternatively, onions can be directly sown in the soil for production. This eliminates all the fertilizer and other management requirements of transplant production. However, more herbicide applications are needed, and satisfactory weed control is still not often achieved with direct-seeded onions. Timing and seedbed preparation are critical for successfully growing onions from direct seeding.

For direct seeding, onion seeds should be sown on October 15 plus or minus 1 week. This is later than sowing for transplant production but is required to avoid undue seed-stem formation (flowering) in the spring. The soil should be prepared so that it is free of clods and plant residue. The soil surface should be smooth with the proper amount of soil moisture. Soil that is too wet will clog the sowing equipment. Soil that is too dry may result in the seeder riding up on the soil and not sowing the seed at the proper depth. Seeds should be sown with a precision seeder, such as a vacuum planter, set to sow seed at 4–6 in. in-row at a depth of 1⁄4–1⁄2 in. deep. The plant stand will be like transplanted onions with four rows on a slightly raised bed with 12–14 in. between the rows. Direct sowing can save a tremendous amount on costs and labor; however, care must be exercised to correctly sow the seed since you will only have one chance to get it right.

Table 1. Soil Recommendations. Nitrogen fertilizer recommendations are based on growing region (soil type), and recommendations for phosphorus and potassium are based on soil test analysis for plant bed onion production (growing bare-ground seedlings for transplants).

pH	**N (lb/acre)**		**Soil test P & K**	**P (lb/acre)**	**K (lb/acre)**
	Coastal Plain	**Piedmont**			
6.0–6.5	100–130	90–120	Low	120	120
			Medium	90	90
			High	60	60
			Very high	30	30
			Overload	0	0

Variety Selection and Characteristics

As mentioned earlier, the type of onion grown in southern Georgia is a short-day onion that bulbs during the short days of winter (> 11 hr daylength). Although limited research has been conducted in this area, it may be possible to grow intermediate-day onions in northern Georgia; however, they would not be as mild as the Vidalia onions grown in southern Georgia.

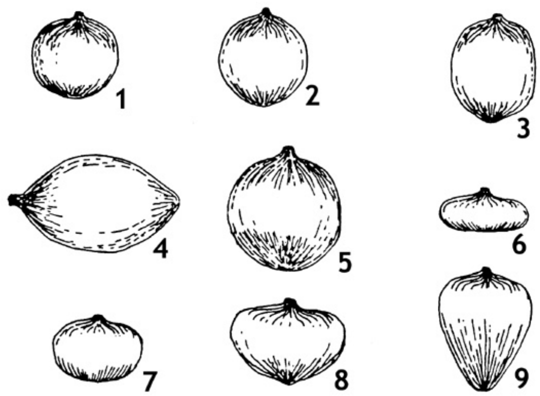

Figure 1. Onion Bulb Shapes. 1. flattened globe; 2. globe; 3. high globe; 4. spindle; 5. Spanish; 6. flat; 7. thick flat; 8. 'Granex'; 9. top. Illustration: Courtesy of Texas A&M University.

The Vidalia onion industry is controlled by a federal marketing order that is administered by the Vidalia Onion Committee and the Georgia Department of Agriculture. This market order defines what types of onions can be grown and marketed as a Vidalia onion. A Vidalia onion must be a yellow 'Granex' type. These onions should be slightly flattened, broader at the distal end (top) and tapering to the proximal end (bottom) (Figure 1). In addition, rules have given the Georgia Department of Agriculture the authority to determine acceptable varieties for the Vidalia industry. Under these rules, the University of Georgia has been mandated to test all onion varieties for 3 years before making recommendations to the Georgia Commissioner of Agriculture. Varieties that the Georgia Department of Agriculture have recommended to be grown as Vidalia onions are listed in Table 2.

Table 2. List of Approved Vidalia Onion Varieties (2024).

Variety	Source	Season
NUN 1011	Nunhems USA Inc.	Early
10258, aka A1298	Hazera Seeds	Mid
369, aka J3009	Bejo Seeds Inc.	Mid
Allison	Bejo Seeds Inc.	Late
Candy Ann	Solar Seed	Early
Candy Joy, aka SH1110	Solar Seed	Early

Candy Kim	Solar Seed	Early
Century	Seminis Seed	Late
DP 1407	D. Palmer Seed	Early
Early Sweet	D. Palmer Seed	Early
EMY 55126	Emerald Seed	Late
EMY 55455	Emerald Seed	Late
EMY 55457	Emerald Seed	Late
Fast Tack, aka 3253	Shamrock	Early
Georgia Boy	D. Palmer Seed	Late
Gilmore 26	Pike	Late
Granex Yellow PRR	Seminis Seed	Late
Macon	Bejo Seeds Inc.	Late
Maragogi	Bejo Seeds Inc.	Mid
New Frontier	Wannamaker Seed	Early
Nun 1014, aka NUN 5901	Nunhems USA Inc.	Late
OSYF10-4021	Crookham	Mid
OSYF12-7091	Crookham	Mid
Pirate	Bejo Seeds Inc.	Mid
Plethora, aka NUN 1006	Nunhems USA Inc.	Mid
Quick Start	Shamrock	Early
Sapelo Sweet	D. Palmer Seed	Mid
SON 404Y, aka XON 404Y	Sakata Seed	Late
Super Ex, aka CSC 500	American Takii, Inc	Late
Sweet Agent	Seminis Seed	Early
Sweet Azalea, aka SV 3524	Seminis Seed	Late
Sweet Magnolia, aka SV 4790	Seminis Seed	Late
Tania, aka J3016	Bejo Seeds Inc.	Mid
Vidora, aka NUN 1003	Nunhems USA Inc.	Early
WI-129	Wannamaker Seed	Early

Onion varieties grown in southeast Georgia fall into three broad maturity categories: early, mid-season, or late. There can, however, be considerable overlap in these categories, and not all varieties will perform the same according to their maturity from one year to the next.

Along with maturity, varieties can perform differently on a wide range of quality attributes and yield. Varieties can differ in pungency, sugar content, disease resistance, seed stem formation, double centers, bulb shape, and bulb size. Growers should consider all of these characteristics when making decisions on variety selection. Growers wishing to try new varieties should consult UGA variety trial results. Trial results should be examined over several years to get a true picture of a variety's potential. Even after evaluating trial data, growers considering new varieties should grow them on limited acreage to better understand their performance potential under their growing conditions. In addition, growers wishing to grow Vidalia onions should check with the Georgia Department of Agriculture for the varieties that are actively allowed.

Soils and Fertilizer Management for Mature Dry Bulb Onions

Onions grow best on fertile, well-drained soils. Tifton series 1 and 2 soils are commonly found in the Vidalia onion area and are well-suited for onion production. However, most sandy loam, loamy sand, or sandy soil types will be advantageous to sweet onion production. These soils contain sandy surface horizons that are inherently low in sulfur, which allows greater flexibility in sulfur management to produce sweet onions. Avoid soils with heavy clay content and coarse sandy soils. Clay soils tend to have a higher sulfur content, which can accumulate in the bulb and lead to pungent onions. Exceedingly sandy soils are more difficult to manage because they are prone to leaching and drying, thus requiring more fertilizer and water.

In sweet onion production, soil characteristics are important to consider for managing the highly-leachable nutrients, nitrate (NO_3^-) and sulfate (SO_4^{2-}), that are associated with pungency. Nitrate and sulfate are negatively charged particles that adhere poorly to sand particles but can attach to clay, particularly at low pH. Many of the upland soils in the region, like the Tifton and Dothan series, have relatively shallow claypans (11–22 in.) that can accumulate leached nitrate and sulfate, allowing onion roots to access these subsoil nutrient deposits late in the season when the plant matures (Table 3). Therefore, to avoid high pungency, onions grown on these soils should receive nitrogen and sulfur fertilizer application rates at the lower end of the recommended ranges. However, soils like the Pelham and Leefield series that have sandy textures deep within their profiles are unlikely to accumulate nitrate and sulfate within the onion rooting zone and should be fertilized at the upper end of the recommendation ranges.

Table 3. Soil Specifications. This list includes some of the common soil series in the Piedmont and Coastal Plains regions of Georgia, with their topsoil and subsoil texture classification, and the typical depth ranges to clayey horizons (claypan (soil Bt horizon)) within the profile.

Region	Soil Series	Topsoil Texture	Subsoil Texture	Typical Depth to Claypan (in.)
Piedmont	Cecil	Sandy Loam	Clay	8–26
	Pacolet	Sandy Loam	Clay	3–23
	Cartecay	Loam	Sandy loam	>60
	Chestatee	Sandy Loam	Sandy Clay Loam	9–13
Coastal Plain	Dothan	Sandy Loam	Sandy Clay Loam	13–22
	Tifton	Loamy Sand	Sandy Clay Loam	11–22
	Fuquay	Sand	Sandy Clay Loam	34–45
	Pelham	Loamy Sand	Sandy Clay Loam	34–50
	Leefield	Loamy Sand	Sandy Clay Loam	23–28

Fertilizer and lime requirements should always be based on a recent, properly obtained soil sample. Check with your county Extension office or crop consultant regarding proper procedures for soil sampling and interpretation of results. Obtain the soil sample a few months prior to crop establishment to determine lime requirements and make necessary lime applications in a timely manner. If soil test results show a pH below 6.0, apply and disk in dolomitic lime 2 to 3 months before land preparation to bring the pH to the optimum range of 6.2 to 6.5. It is essential to apply sufficient lime to keep the soil pH above 6.0. Low pH can cause nutrient deficiencies during the growing season. If the pH is not corrected at the beginning of the onion season, nutrient deficiencies could occur during the year and reduce yield. Calcium and phosphorous deficiencies can often be linked to low pH, even though soil tests indicate adequate levels. But phosphorus deficiencies due to low pH can be difficult to correct during the growing season.

Splitting fertilizer applications ensures good yields and lessens the amount lost from leaching. Preplant fertilizer will vary with the natural fertility and cropping history. Proper application methods and function of various nutrients are outlined below. Table 4 shows a suggested fertilizer program for a soil testing medium in P and K.

Nitrogen (N), especially in nitrate (NO_3^-) form, is extremely leachable. If too little nitrogen is available, onions can be severely stunted. High nitrogen rates are believed to produce succulent plants that are more susceptible to chilling or freezing injury, disease, and to production of flower stalks. Onions that are heavily fertilized with nitrogen are not believed to store well. Finally, excess nitrogen late in the growing season is believed to delay maturity and may increase disease at harvest. Make the final nitrogen application at least 4 weeks prior to harvest. Rates of nitrogen will vary depending on soil type, rainfall, irrigation, plant populations, and method and timing of applications. For dry bulb production from transplanting onions, it should require between 100–120 lb nitrogen/acre. Recent research suggests that preplant applications of N can be minimized for Vidalia onions. Prior recommendations of incorporating 25%–30% of N at planting are inefficient, as most of the nitrogen is leached and not taken up by transplants.

Phosphorus (P) is essential for rapid root development. It is found in adequate levels in most soils but is not readily available at low soil temperatures. Because of these factors, traditionally, phosphorus has been applied preplant and incorporated before transplanting. However, research has shown that complete homogenized or blended fertilizers containing phosphorous applied after planting have been effective at providing adequate phosphorous for crop growth. Table 4 shows the recommended phosphorus to be applied based on various soil test levels.

Potassium (K) is an important factor in plant water relations, cell-wall formation, and energy reactions in the plant. Potassium is also subject to leaching from heavy rainfall or irrigation. Therefore, it is best to split potassium applications by incorporating 30% to 50% of the recommended phosphorus before planting and splitting the remainder in one to two sidedress applications. As with phosphorus, most complete fertilizers contain potassium, which is often applied in 2 to 3 applications after planting. Table 4 lists recommended potassium applications based on soil test results.

Sulfur (S) is an essential element for plant growth. Early applications of sulfur are advisable in both direct-seeded and transplanted onions. To minimize pungency, fertilizers that contain sulfur should not be applied after the end of January. Research conducted in Georgia on sulfur and onion pungency has shown that pungency (pyruvate analysis) of mature onions increases with high rates of sulfur or whenever sulfur applications are made after late January. Therefore, late sulfur applications should be avoided unless the onions exhibit S deficiency. Do not eliminate sulfur from the fertility program completely. Apply 20 to 40 lb of elemental sulfur, with half incorporated at transplanting or seeding and half applied at the first sidedress application. Do not apply sulfur at rates higher than 20–40 lb/acre.

Boron (B) is required by direct-seeded or transplanted onions in the field. If the soil test shows boron levels are low, apply 1 lb of boron per acre and incorporate it before transplanting or seeding. Do not exceed the recommended amount because boron can be toxic to onions.

Zinc (Zn) levels determined to be low by soil testing can be corrected by applying 5 lb of zinc per acre. Excessive amounts of zinc can be toxic, so apply only if it is needed. Zinc is usually added in the preplant fertilizer.

Magnesium (Mg) levels in the soil must be adequate for good onion growth. If dolomitic limestone is used in the liming program, it will usually supply some of the required magnesium. However, if soil pH is adequate and the soil-test magnesium level is low, apply 25 lb of magnesium per acre in the preplant fertilizer.

Slow-release fertilizers have been introduced to the Vidalia growing region. These fertilizers have performed well and can be considered in a fertility program. Slow-release fertilizers, however, have not proven satisfactory for a single pre-plant fertilizer application and perform best when combined with applications of a complete fertilizer in January or February.

Table 4. Sample Fertilizer Recommendations for Transplanted Onions With a Population of 80,000–100,000 Plants Per Acre. Adjust for soil test levels other than medium phosphorus and medium potassium.

Timing	**Amount (lb/acre)**	**Type**	**Method**	**N**	**P2O5**	**K2O**	**S**
At or after planting (December)	350	5-10-15 with 3% S	Broadcast	15	30	45	10.5
Early January	350	5-10-15 with 3% S	Sidedress	15	30	45	10.5
Late January	350	5-10-15 with 3% S	Sidedress	15	30	45	10.5
Early February	200	15.5-0-0	Sidedress	31	0	0	0
Late February	200	15.5-0-0	Sidedress	31	0	0	0
Total				**107**	**90**	**135**	**31.5**

Routine visual inspections of onion fields are important to watch for nutrient deficiencies. During periods of high rainfall or frequent irrigation, however, you should be particularly aware of the potential for nutrient deficiencies to occur. During seasons with high levels of precipitation, growers may need to add up to 20 more lb nitrogen per acre to account for leaching of nutrients.

Deficiencies of major nutrients cannot be feasibly corrected through foliar nutrient applications. Therefore, it is important to properly manage soil fertility to maintain optimum growth and development. Some deficiencies of minor elements can be remedially corrected through foliar applications. However, it is always best to supply adequate amounts of these nutrients through your basic soil fertility program.

Table 5. Potassium and Phosphorus Application Recommendations. These are based on soil test ratings of each nutrient for bulb production. Nitrogen is recommended based on soil type.

	Potassium					
Phosphorus		Low	Medium	High	Very High	Overload
	(Lb N-P_2O_5-K_2O per acre)					
	Low	*-120–120	*-120–90	*-120–60	*-120–30	*-120–0
	Medium	*-90–120	*-90–90	*-90–60	*-90–30	*-90–0
	High	*-60–120	*-60–90	*-60–60	*-60–30	*-60–0
	Very High	*-30–120	*-30–90	*-30–60	*-30–30	*-30–0
	Overload	*-0–120	*-0–90	*-0–60	*-0–30	*-0–0

*Nitrogen recommendations: Coastal Plain Soils: 100–130 lb N/acre. Piedmont, Mountain, and Limestone Valley Soils: 90–120 lb N/acre.

Plant Tissue Analysis

Plant tissue analysis is an excellent tool to evaluate crop nutrient status. Periodic tissue analysis can be used to determine if fertility levels are adequate or if supplemental fertilizer applications are required. Tissue analysis can often be used to detect nutrient deficiencies before they are visible.

Plant tissue analysis is accomplished by sampling the most recently mature leaves of the plant. A sample of 20–30 leaves should be taken from the field area(s) in question. Check with your county Extension office or crop consultant on proper tissue analysis techniques. The UGA Plant, Soil, and Water Testing Laboratory can analyze your samples. Table 5 shows critical ranges for nutrient concentrations in onion tissue for the crop stage just prior to bulb initiation.

Table 5. Plant Tissue Analysis Critical Values for Dry Bulb Onions.

Nutrient	Percent						Parts per million					
	N	P	K	Ca	Mg	S	Fe	Mn	Zn	B	Cu	Mo

Status												
Deficient	<2.0	0.20	1.5	0.6	0.15	0.2	50	10	15	10	5	-
Adequate	2.0–3.5	0.20–0.50	1.5–3.50	0.6–0.8	0.15–0.30	0.2–0.6	50–100	10–20	15–20	10–25	5–10	-
High	>3.5	0.50	3.5	0.8	0.30	0.6	100	20	20	25	10	-
Toxic	-	-	-	-	-	-	-	-	-	-	100	-

Adapted from "Vegetable Production Guide for Florida," by University of Florida Cooperative Extension Service, 1999.

Cultural Practices

Transplants are generally set in November to December. They can, however, be successfully set in January. Plants set in February will generally be smaller at maturity and should be avoided unless replanting after a severe freeze event. Early varieties should be planted prior to the end of December. If planted late, they will have lower yields and smaller bulbs because they are strongly daylength sensitive and will ***go down*** (tops lodge at the neck) or reach maturity earlier than other varieties.

Transplants are field set on slightly raised beds approximately 4 ft wide. Most growers are on beds that are 72 in. or 76 in. center to center. Optimum plant populations range from 85,000–110,000 plants per acre. There are several types of bed configurations, from 4–6 rows per bed with in-row holes spaced 4–5 in. apart to achieve these populations (Figure 2). The spacing is determined by peg spacing on a pegger used to place holes in the bed surface 1 to 2 in. deep (Figure 3). Transplants are set by hand in each hole.

Onions grow slowly during the cool short days of winter. Because of this, fertilizer, pesticide, and irrigation practices must minimize disease while maintaining optimum growing conditions.

Figure 2. Typical Onion Field. **Figure 3.** Pegger.

Knowing the variety and carefully inspecting the crop is the best method to determine maturity Harvest maturity and digging timing varies considerably due to genetic background. Early maturing onions with Japanese genetics will need to wait as close as possible to 100% tops down. The key with Japanese varieties is not necessarily about the tops, but the firmness of the bulb. You are really waiting to make sure the bulbs are firm and not soft anymore, and this is usually when all the tops have fallen. Soft bulbs are still immature, and if they are clipped when soft they tend to remain soft. Inspectors/customers can reject soft onions There are newer early maturing varieties, such as 'Vidora', that are not of Japanese background that can be dug without waiting on the tops to fall. Most of the time growers will dig them when they reach the size they are needing for customers. This trend is consistent with other later maturing onions as well, with growers digging them when they get the size they want. One important tip to remember when digging onions before they have reached "tops-down" maturity is to allow at least 3–5 days after digging to allow them to stop growing before they are clipped. If they are clipped too early, the tops will continue to "grow out" from the cut, and inspectors reject these onions as immature. Onions harvested too early may be soft and not dry down sufficiently during curing. If the onions are harvested too late, there may be an increase in postharvest diseases and sunscald on the shoulder of the bulb.

Onions are prone to physiological disorders that growers should try to minimize. One such disorder is known as splits, or doubles. This condition is caused by cultural and environmental factors, as well as being influenced by genetics. Over-fertilization, uneven watering, and temperature fluctuations (particularly below 20 °F) are all believed to have an influence on double formation. Some varieties are more prone to the production of doubles than others. Planting these types should be avoided altogether, since there are plenty of newer varieties available that are not susceptible to doubling.

Onions are biennials that form bulbs in the first year that will act as a food source the following year when the plant flowers. The process of flowering in onions is called ***bolting***. A seed stalk or scape will form very quickly and appear to bolt up. These flower stalks or seed stems can form in the first year if appropriate environmental conditions occur and plant size is favorable. Cool temperatures during the latter part of the growing season (March and April), when plants are relatively large, can result in a high percentage of seed stems. There also appears to be a variety component to seed stem formation.

Onions can generally withstand light to heavy frosts, but hard freezes can result in onion damage. The amount of damage may be directly related to acclimation of onion plants. Young transplants may be affected by a freeze to a greater extent than established plants that have been exposed to progressively cooler temperatures. Freeze injury may be readily detectable as translucent or water-soaked outer scales of the bulbs. A day or two after the freeze event, onions should be cut transversely to see if translucent scales are present. In some cases, freeze damage may not be readily detectable for several days. In these cases, the growing point may have been affected, and subsequent growth will be abnormal, increasing the incidence of doubles. Having adequate soil moisture can help reduce the impact of some freeze events, as the water in the soil can absorb more heat during the day, which can then radiate from the soil to help protect plants at night.

Onions may develop disorders that are not associated with insect, disease, or nutrient problems. One example is greening. This occurs when the bulb is exposed to sunlight for an extended period. Early fertilizer application is needed to develop a strong, healthy top, which shades the bulb during development.

Sunscald will occur at the shoulders of all onions that are exposed to sunlight for an extended period. Bulb sun scalding can occur when maturity is reached and harvest is delayed. Harvest should occur as soon as possible after the crop has matured. Scales several layers deep will dry and turn brown. The internal tissue may actually cook under severe conditions, becoming soft and translucent.

Translucent scale is a physiological disorder similar in appearance to freeze injury. The big difference is that freeze injury will always affect the outer scales, whereas translucent scale may first appear on scales several layers deep in the bulb. Translucent scale is a postharvest phenomenon caused by high CO_2 in storage facilities. This is most likely to occur in controlled atmosphere storage. CO_2 levels above 8% will increase the chance of translucent scale. Growers and packers should carefully monitor storage facilities to prevent this.

Physical damage to onions may appear that can be confused with botrytis leaf blight (see disease section). This damage is usually caused by wind-blown sand or hail. Strong winds can cause flecking of leaves, particularly in fields with dry sandy soils. Hail damage will usually be more severe with large white or yellow lesions on the leaves (0.125–0.25 in. in diameter). The shoulders of the exposed bulbs will often have a dimpled feel. In severe cases, the crop can be defoliated and destroyed.

Plants may occasionally exhibit a striped appearance. If this is widespread in a field, sulfur deficiency is the probable cause (see fertility section). If it appears on an isolated plant, it is probably a ***chimera***. Chimeras result when a mutation occurs in the meristematic tissue (growing point), resulting in a striped plant. This should not be a concern.

Irrigating Sweet Onions in Georgia

Because of the importance of water management in onions, all commercially-grown onions in Georgia are irrigated. Research and extension trials in Georgia have indicated that properly irrigated onions will yield 25% to 50% more than dry land onions. Irrigated fields typically yield a higher percentage of jumbo bulbs, which generally bring a higher price on the market. Irrigated onions are sweeter and less pungent than dryland onions, which is especially important for Vidalia onions.

Irrigation System Options

Almost all onions in Georgia are sprinkler irrigated. The two most used systems are center pivots and traveling guns. Other irrigation systems can be used if they can supply the needed water evenly over the entire field.

Irrigation Scheduling

Water use for onions varies considerably throughout the growing period and with weather conditions. The peak water demand for onions can be as high as 1.5 to 2 in. per week. Peak use generally occurs during the latter stages of bulb enlargement, especially during periods of warm weather.

Transplanted onions should be watered very soon after setting. About ½ in. applied at this time will help establish good contact between the soil and roots and assure a good stand.

During the next 2 or 3 months, the plants will be small and have a relatively shallow root system. The fall months also tend to be some of the driest months in Georgia. During this period, irrigation should be applied whenever the soil becomes dry in the top 6 in. Irrigation amounts should be limited to about ½ in. per application during this stage. Irrigation applications are typically infrequent during this period, since the plants are small, and water demand is relatively low.

When the bulbs begin to enlarge, water demand will gradually increase, as will the need to irrigate when the weather turns dry. Rooting depths at this stage are typically 12 in. or less. Because of the shallow rooting depth, irrigation applications should not exceed 1 in. Typical applications should range between 0.3 and 0.5 in. for loamy soils and for sandy soils, respectively. During dry weather, irrigate two or three times per week, especially when the weather is warm. Of course, when temperatures are cool, irrigations may be less frequent.

Unlike most other crops, onions do not generally wilt when they experience moisture stress. Since moisture stress is difficult to detect by visual inspection, it is very helpful to monitor soil moisture. This can be done by installing moisture sensors in the soil. Install soil moisture sensors at two depths, one near the middle of the root zone and one near the bottom. Common practice is to install one at 4 to 6 in. and one at 10 to 12 in.

In general, if the system requires 3 days to water the entire field, then you should install at least three soil moisture stations, evenly spaced around the field. Each station will consist of two sensors, one shallow and one deep. You should monitor the readings on the soil moisture sensors at least three times per week when the weather is dry.

Chemical Application

Two types of sprayers, boom and air-assisted, are used for applying insecticides, fungicides, herbicides, and foliar fertilizers. Air-assisted sprayers (Figure 4) utilize a conventional hydraulic nozzle, plus air to force the spray into the plant foliage. Boom sprayers (Figure 5) get their name from the arrangement of the conduit that carries the spray liquid to the nozzles. Booms or long arms on the sprayer extend across a given width to cover a swath as the sprayer passes over the field.

Figure 4. Air-Assisted Sprayer.

Figure 5. Boom Sprayer.

Pumps

Three factors to consider in selecting the proper pump for a sprayer are capacity, pressure, and resistance to corrosion and wear. The pump should be of proper capacity or size to supply the boom output and to provide for agitation 5 to 7 gallons per min (gpm) per 100-gallon tank capacity. Boom output will vary depending on the number and size of nozzles.

Nozzles

Nozzle selection is one of the most important decisions to be made related to pesticide applications. The type of nozzle determines not only the amount of spray applied, but also the uniformity of application, the coverage obtained on the sprayed surfaces, and the amount of drift that can occur. Each nozzle type has specific characteristics and capabilities and is designed for use under certain application conditions. The types that are commonly used for ground application of agricultural chemicals for onions are fan and cone nozzles.

Herbicides

The type of nozzle used for applying herbicides is one that develops a large droplet and has no drift. The nozzles used for broadcast applications include the extended range flat fan, drift reduction flat fan, turbo flat fan, flooding fan, turbo flooding fan, turbo drop flat fan, and wide-angle cone nozzles. Operating pressures should be 20 to 30 psi for all except drift reduction and turbo drop flat fans, flooding and wide-angle cones. Spray pressure more than 40 psi will create significant drift with flat fan nozzles. Drift reduction and turbo drop nozzles should be operated at 40 psi. Flooding fan and wide-angle cone nozzles should be operated at 15 to 18 psi. These nozzles will achieve uniform application of the chemical if they are uniformly spaced along the boom. Flat fan nozzles should overlap 50% to 60%.

Insecticides and Fungicides

Hollow cone nozzles are used primarily for plant foliage penetration for effective insect and disease control when drift is not a major concern. At pressures of 60 to 200 psi, these nozzles produce small droplets that penetrate plant canopies and cover the underside of the leaves more effectively than any other nozzle type. The hollow cone nozzles produce a cone-shaped pattern with the spray concentrated in a ring around the outer edge of the pattern. Even fan and hollow cone nozzles can be used for banding insecticides or fungicides over the row.

Nozzle Material

Various types of nozzle bodies and caps, including color-coded versions, and multiple nozzle bodies are available. Nozzle tips are interchangeable and are available in a wide variety of materials, including hardened stainless steel, stainless steel, brass, ceramic, and various types of plastic. Hardened stainless steel and ceramic are the most wear-resistant materials. Stainless steel tips, even when used with corrosive or abrasive materials, have excellent wear resistance. Plastic tips are resistant to corrosion and abrasion and are proving to be very economical for applying pesticides. Brass tips have been common but wear rapidly when used to apply abrasive materials such as wettable powders. Brass tips are economical for limited use, but other types should be considered for more extensive use.

Water Rates (GPA)

The grower who plans to use spray materials at the low water rate should follow all recommendations carefully. Use product label recommendations on water rates to achieve optimal performance. Plant size and condition influence the water rate applied per acre. Examination of the crop behind the sprayer before the spray dries will give a good indication of coverage.

Agitation

Most materials applied by a sprayer are in a mixture or suspension. Uniform application requires a homogeneous solution provided by proper agitation (mixing). The agitation may be produced by jet agitators, volume boosters (sometimes referred to as hydraulic agitators), and mechanical agitators. These can be purchased separately and installed on sprayer tanks. Continuous agitation is needed when applying pesticides that tend to settle out, even when moving from field to field or when stopping for a few minutes.

Nozzle Arrangements

When applying insecticides and fungicides, use a broadcast boom arrangement. Place nozzles on 10 to 12 in. centers for complete coverage of the plant.

Calibration

The procedure below is based on spraying 1/128 of an acre per nozzle or row spacing and collecting the spray that would be released during the time it takes to spray the area. Because there are 128 oz of liquid in 1 gallon, this convenient relationship results in ounces of liquid collected being directly equal to the application rate in gallons per acre.

Calibrate with clean water when applying toxic pesticides mixed with large volumes of water. Check uniformity of nozzle output across the boom. Collect from each for a known period. Each nozzle should be within 10% of the average output. Replace with new nozzles if necessary. When applying materials that are appreciably different from water in weight or flow characteristics, such as fertilizer solutions, etc., calibrate with the material to be applied. Exercise extreme care and use protective equipment when the active ingredient is involved.

Table 6. Distance to Measure to Spray 1/128 acre. One ounce discharged equals 1 gallon per acre.

Nozzle spacing (in.)	Distance (ft)	Nozzle spacing (in.)	Distance (ft)
6	681	20	204
8	520	22	186
10	408	24	170
12	340	30	136
14	292	36	113
16	255	38	107
18	227	40	102

To determine a calibration distance for an unlisted spacing, divide 340 by the spacing expressed in feet. Example: Calibration distance for a 13-in. band = 340 ÷ (13 ÷ 12) = 313 ft.

1. From Table 6, determine the distance to drive in the field. For broadcast spraying, measure the distance between nozzles. For band spraying, use band width. For over-the-row or directed, use row spacing.
2. Measure the time (seconds) to drive the required distance with all equipment attached and operating. Maintain this throttle setting! (Two or more runs are suggested)
3. With the sprayer sitting still and operating at the same throttle setting or engine RPM as used in step 2, adjust the pressure to the desired setting. The machine must be operated at the same pressure used for calibration.
4. For broadcast application, collect spray from one nozzle or outlet for the number of seconds required to travel the calibration distance.

5. For band application, collect spray from all nozzles or outlets used on one band width for the number of seconds required to travel the calibration distance.
6. For row application, collect spray from all outlets (nozzles, etc.) used for one row for the number of seconds required to travel the calibration distance.
7. Measure the amount of liquid collected in fluid ounces. The number of ounces collected is the gallons per acre rate on the coverage basis indicated. For example, if you collect 18 oz, the sprayer will apply 18 gallons per acre. Adjust applicator speed, pressure, nozzle size, etc., to obtain the recommended rate. If speed is adjusted, start at step 2 and recalibrate. If pressure or nozzles are changed, start at step 3 and recalibrate.

Diseases of Vidalia Onions

Onion diseases can cause severe losses by reducing yield and quality of marketable onions. These onion diseases can occur in seedbeds, production fields, and in storage. Disease management requires a systems approach that involves practices such as rotation, sanitation, optimum fertilization, preventive fungicide/bactericide applications, harvest timing, and proper harvesting, handling, and storage. If one or more of these practices are omitted, disease management is significantly compromised.

Fungicide Recommendations for Disease Management of Onions

For currently labelled and recommended insecticides for diseases of onions, please refer to the current Georgia Pest Management Handbook Commercial Edition.

Fungal Diseases Affecting Roots and Underground Plant Parts

Pink Root

Pink root, caused by the fungus *Phoma terrestris*, is the most common and damaging root disease of onions in Georgia. This disease is greatly enhanced by stresses imposed on plants, such as heat, cold, drought, flooding, and nutrient toxicities/deficiencies. The fungus reproduces and survives indefinitely in soil; therefore, continuous production of onions in the same field results in increased losses to pink root.

Symptoms: The name of this disease is its most descriptive symptom. Roots infected by the pink root fungus turn pink or sometimes appear purplish (Figure 6). Infected roots eventually turn brown and deteriorate. Onions in both seedbeds and production fields can become infected. Early infected plants may die or may not produce usable bulbs. Later infected plants are stunted, producing small, unmarketable bulbs.

Management Options: Utilizing a long rotation to non-related crops (3–7 years) can work as a management strategy for reducing losses to pink root; however, this may not always be possible. Also, correct soil tilth, fertility, and water management will reduce stresses that enhance disease development. The optimum temperature for growth and infection by pink root is 79 °F; therefore, delaying planting until soil temperatures average 75 °F or below will allow roots to grow and develop before temperatures that enhance infection. Harvesting onions prior to soil temperatures reaching 79 °F will allow onions to escape further pink root infection. Fumigation with metam sodium, chloropicrin, and 1,3-D dichloropropene (Telone) have been shown to increase yields when onions have been planted in fields heavily infested with pink root. Application of penthiopyrad (Fontelis) 2 weeks after planting using a high volume of water (50 gallons/acre or more) has been shown to reduce pink root. Onion varieties resistant to pink root that also have horticulturally acceptable qualities should also be considered.

Figure 6. Roots of Onion Infected with Pink Root (*Phoma terrestris*).

Fusarium Basal Rot

Fusarium basal rot is caused by the fungus *Fusarium oxysporum* f. sp. *cepae*. This disease occurs sporadically in the Vidalia area. Losses to this disease can occur in the field and later when onions are in storage. Like pink root, Fusarium basal rot can build up in soils where onions are grown year after year.

Symptoms: Symptoms may be observed in the field as yellowing leaf tips which later become necrotic. This yellowing and/or necrosis may progress towards the base of infected plants. Sometimes leaves of infected plants may exhibit curling or curving. Infected bulbs, when cut vertically, will show a brown discoloration in the basal plate (Figure 7). This discoloration will move up into the bulb from the base. In advanced infections, pitting and decay of the basal plate, rotten sloughed-off roots, and white, fluffy mycelium are all characteristic symptoms and signs of Fusarium basal rot. Sometimes, infected bulbs may not show symptoms in the field but will rot in storage.

Management Options*:* Although this disease sporadically occurs in Georgia, particularly in fields with poor crop rotation, damage to yield and quality can be substantial if not managed well. Like pink root, utilizing a long rotation (4 or more years) to non-related crops can be a key management strategy for reducing losses to Fusarium basal rot. Use of healthy transplants, avoiding fertilizer injury, and controlling insects will reduce losses to basal rot. Storing onions at

34 °F will help minimize losses. Resistance to Fusarium basal rot has been identified in some commercial onion cultivars. (check on current varieties)

Figure 7. Onion Basal Plate Infected with Fusarium Basal Rot.

Fungal Diseases Affecting Aboveground Plant Parts

Figure 8. Gray Sporulation of Botrytis Neck Rot.

Figure 9. Reddish-Brown Discoloration of Onion Scales Caused by Botrytis Neck Rot.

Botrytis Neck Rot

Botrytis neck rot is the most damaging fungal disease that affects onions in Georgia, with severe losses occurring both in the field and in storage. The fungus causing botrytis neck rot, *Botrytis allii*, can survive in the soil or on rotting bulbs as sclerotia. *Botrytis conidia* may arise from these sclerotia and be carried by wind to spread the disease.

Symptoms: Although the bulk of losses to botrytis neck rot are in storage, severe losses can be experienced in field situations. Plants infected in the field exhibit leaf distortion, stunted growth, and splitting of leaves around the neck area. A grayish sporulation of the fungus may be observed between leaf scales near the neck area (Figure 8). In storage, infection can be internal with no discernible symptoms on the onion. It is not until onions are removed from storage that the infection becomes evident. Apparently, the infection enters the neck and continues to grow undetected in storage until the onions are removed. It has been demonstrated that botrytis neck rot is not capable of sporulation in controlled atmosphere storage (high CO_2, low O_2, refrigerated storage), but continues to grow and destroy infected onion tissue. Infected tissue is sunken, water-soaked, and spongy with a reddish-brown color (Figure 9). The grayish fungal sporulation can be seen between scales in infected bulbs. The gray mold will later appear on the onion surface and may give rise to hard, black sclerotia.

Management Options: Harvesting healthy mature onions with a well-dried neck after at least 72-hr of field curing will greatly reduce Botrytis neck rot incidence in storage. Avoid over-fertilization and high plant populations, which lead to delayed maturity and reduced air movement through the canopy, respectively. Curing onions with forced air heated to 98 °F will cause the outer scales to dry down and become barriers to Botrytis infection. Storing onions near 34 °F at approximately 70% relative humidity reduces the growth and spread of neck rot. Sanitation through deep soil turning and destroying cull piles helps reduce the amount of *Botrytis allii* inoculum in production fields. A combination of boscalid (Endura) and pyraclostrobin (Cabrio), as well as these products individually, has been shown to give good control of Botrytis neck rot. Using any fungicide should be integrated into a complete system of disease control. In addition, follow label directions for use. For questions on a specific program of disease control, contact your county extension agent.

Figure 10. Pale Lesions Caused by Botrytis Leaf Blight.

Botrytis Leaf Blight

Botrytis leaf blight, caused by *Botrytis squamosa,* is another disease caused by the genus Botrytis. However, this fungus infects onion foliage. This fungus survives in onion debris in the soil or in cull piles as sclerotia. The sclerotia produce conidia that become airborne and spread to foliage in production fields. Infection is greatly increased by long periods of leaf wetness and temperatures around 80 °F.

Symptoms: Initial symptoms of botrytis leaf blight are small (less than ¼ in. in length) whitish, necrotic spots surrounded by pale halos (Figure 10). Spots often become sunken and elongated. Severely blighted leaves may result in reduced bulb size.

Management Options: Preventative spray of a program consisting of benzovindiflupyr + difenoconazole (Aprovia Top), difenoconazole + cyprodinil (Inspire Super), fluopyram + difenoconazole (Luna Flex), and fludioxonil + pydiflumetofen (Miravis Prime) can effectively manage this disease. Destruction of cull piles, deep soil turning, and long rotations are also recommended to reduce losses to this disease.

Figure 11. Elliptical Lesion Characteristic of Purple Blotch.

Purple Blotch

Purple blotch, caused by *Alternaria porri*, is probably one of the most common diseases of onion and is distributed worldwide. The fungus overwinters as mycelium in onion leaf debris. During periods favorable for sporulation (leaf wetness or relative humidity of 90% or higher for 12 or more hr) inoculum becomes windborne and spreads to new foliage. Infection is highest at 77 °F. Older plant tissue is more susceptible to infection by purple blotch. Thrips feeding is thought to increase the susceptibility of onion tissue to this disease.

Symptoms: Purple blotch symptoms are first observed as small, elliptical, tan lesions that often turn purplish brown (Figure 11). Concentric rings can be seen in lesions as they enlarge. A yellow halo surrounds lesions and extends above and below the actual lesion itself for some distance. Lesions usually girdle leaves, causing them to fall over. Lesions may also start at the tips of older leaves.

Management Options: Long rotations to non-related crops, good soil drainage, and measures to reduce extended leaf wetness periods will reduce the severity of losses to purple blotch. Preventative spray of a program consisting of azoxystrobin+difenoconazole (Quadris Top), benzovindiflupyr + difenoconazole (Aprovia Top), difenoconazole + cyprodinil (Inspire Super), fluopyram + difenoconazole (Luna Flex), fluazinam (Omega 500), and fludioxonil + pydiflumetofen (Miravis Prime) can effectively manage this disease. These schedules should be intensified later in the season during periods of prolonged leaf wetness and high relative humidity.

Figure 12. Dark Sporulation Indicative of Stemphylium Leaf Blight.

Stemphylium Leaf Blight

This fungal disease, caused by *Stemphylium vesicarium*, has become more widespread in the Vidalia onion growing region during recent years. This disease typically attacks leaf tips, purple blotch lesions, and injured or dying onion leaves and is often identified as purple blotch. Disease cycle and epidemiology are similar to purple blotch. *Stemphylium vesicarium* may enter purple blotch lesions, causing a black fungal growth.

Symptoms: Since this fungus is usually found co-infecting with *Alternaria porri*, symptoms are identical or at least very similar to purple blotch. However, Stemphylium leaf blight lesions appear to contain a darker, more olive brown to black color than do purple blotch lesions (Figure 12). In the case of Stemphylium leaf blight, lesions are often more numerous on the sides of onion leaves facing the prevailing wind. These lesions grow rapidly, coalesce, and cause severe leaf blighting during periods of prolonged leaf wetness.

Management Options: Practices used to suppress purple blotch will generally reduce losses to Stemphylium leaf blight. A fungicide program consisting of fluopyram + difenoconazole (Luna Flex), and fludioxonil + pydiflumetofen (Miravis Prime) can effectively manage this disease. These are the only fungicides thought to be effective against Stemphylium leaf blight.

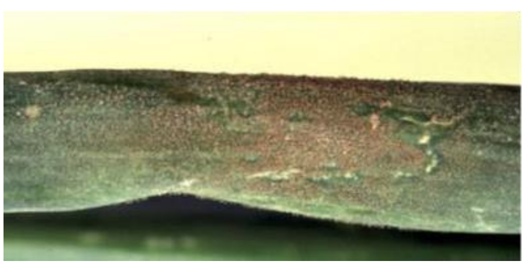

Figure 13. Velvety Sporulation of the Downy Mildew Fungus. Photo by Tom Isakeit, Texas A&M University, 1995.

Downy Mildew

Onion downy mildew, caused by the fungus *Peronospora destructor*, is very common throughout most areas of the world; however, it is rarely observed in the Vidalia onion growing region of Georgia. This fungus can overwinter in plant debris or be brought in on sets or seed. Temperatures between 50 °F and 55 °F, long periods of leaf wetness, and/or high relative humidity (95%) are optimal for infection and spread.

Symptoms: Downy mildew may be first detected in the early morning as a violet, velvety sporulation (Figure 13). With time, infected areas of leaves become pale and later turn yellow. These lesions may girdle the leaf and cause it to collapse. Epidemics may begin in small spots in a field that will spread, mainly during periods of high relative humidity, and cause considerable defoliation.

Management Options*:* Management practices which ensure good airflow and adequate drainage will reduce the risk of high losses to this disease. Avoiding infected planting stock and destroying cull piles reduce available inoculum. Preventive application of fungicides provides the primary control of downy mildew in regions where it is a perennial problem. A fungicide program consisting of ametoctradin + dimethomorph (Zampro), chlorothalonil (Bravo), fluazinam (Omega 500), mefenoxam + copper (Ridomil Gold/copper), and oxathiapiprolin + mandipropamid (Orondis Ultra) can moderately help in managing this destructive disease.

Bacterial Diseases

Figure 14. Collapsed Leaves Caused by Bacterial Streak.

Figure 15. Dark Green Lesions Caused by Bacterial Streak.

Bacterial Streak and Bulb Rot

This bacterial disease of onion, caused by *Pseudomonas viridiflava* and *Pseudomonas alliivorans,* can occasionally be a problem in the southeastern U.S. onion production areas.

Disease is favored by excessive fertilization and prolonged periods of rain during the cool winter months of onion production.

Symptoms: Leaf symptoms initially appear as oval lesions or streaks that later result in the total collapse of the entire leaf (Figure 14). Initially, streaks are usually green and water-soaked but later cause constricted, dark green to almost black lesions near the base of infected leaves (Figure 15). Infected leaves will generally fall off the bulb when any pressure is applied to pull them off. A reddish-brown discoloration has been observed in the inner scales of harvested bulbs.

Management Options: Preventive application of fixed copper materials tank mixed with EBDC fungicides (Maneb, Mancozeb, Manzate, Dithane, Penncozeb, and others) may reduce the incidence and spread of this disease. Avoiding the over-fertilization with nitrogen during winter months may reduce losses to bacterial streak. Practices that reduce post-harvest rot, such as harvesting mature onions, curing onions immediately after clipping, and avoiding bruising or wounding, will help avoid disease problems.

Figure 16. Bleached Center Leaves Caused by the Center Rot Pathogen Pantoea Ananatis.

Center Rot

Center rot, caused by *Pantoea ananatis* and other *Pantoea* species, is another bacterial disease of onions grown in Georgia. Unlike bacterial streak, warm weather favors the development of epidemics of center rot. This bacterial pathogen is also found to be present in many weed species occurring in the Vidalia onion growing region. The pathogen is passively transmitted by thrips upon feeding. Thrips transmission is a major driving factor of center rot infection, as the epidemic often gets initiated with an influx of thrip populations around the second or third week of March in the Vidalia onion region.

Symptoms: Foliar symptoms of center rot are typically observed as severe chlorosis or bleaching of one or more of the center leaves of infected onions (Figure 16). Infected leaves are usually collapsed and hang down beside the onion neck. In harvested bulbs, reddish, collapsed scales near the neck area have been associated with center rot.

Management Options: Thrips management is the cornerstone for effectively managing this disease. Insecticide spray for thrips control, along with a preventative spray of fixed copper materials tank mixed with EBDC fungicides, is recommended to manage this disease. Several onion cultivars have been documented to be more susceptible to center rot and should be avoided. Onions that mature early may avoid center rot losses by being less exposed to the higher temperatures necessary for the development of disease.

Figure 17. Onion Bulb Deterioration Caused by Sour Skin.

Sour Skin

Burkholderia cepacia is the causal agent of this onion bacterial disease. Sour skin primarily affects onion bulbs, but foliar symptoms may also be observed from time to time. This disease usually manifests itself during harvest when temperatures above 85^{o} F are not uncommon.

Symptoms: Foliar symptoms, when observed, are like those of center rot. Scales of infected bulbs develop a cheesy or slimy yellow growth and brown decay (Figure 17). Infected scales may separate from adjacent scales, allowing firmer inner scales to slide out when the bulb is squeezed. Sour skin infected bulbs usually have an acrid, sour, vinegar-like odor due to secondary organisms.

Management Options: Avoidance of overhead irrigation near harvest time will reduce losses to this disease. Also, use practices that reduce the chance of irrigation water becoming contaminated with the sour skin bacteria. Avoid damaging onion foliage before harvest, as this provides wounds for the bacteria to enter bulbs. Do not allow mature onions to remain in fields during the warm climates associated with the later harvest season, as infection and spread of this bacterium is enhanced with higher temperatures. Infected bulbs should be discarded before storing, as disease can spread from infected bulbs to healthy bulbs. Infected onions should not be heat-cured postharvest, as this will rapidly spread the pathogen to uninfected bulbs. Storing onions in cool (32° F) dry areas will prevent bulb-to-bulb spread of sour skin.

Figure 18. Deterioration of the Core Bulb Scales Caused by Bacterial Soft Rot.

Bacterial Soft Rot

Bacterial soft rot, caused by *Pectobacterium carotovor*um, is a common problem in many vegetables, usually during storage. It usually develops in onions after heavy rains or after irrigation with contaminated water. This disease is primarily a problem on mature onion bulbs during warm (68°–85° F), humid conditions.

Symptoms: Field symptoms are very similar to those seen with center rot in that it causes center leaves of onions to become pale and collapse. Infected scales of bulbs are initially water-soaked and later appear yellow or pale brown. In advanced stages of infection, scales become soft and watery and fall apart easily. As the interior of the bulb breaks down, a foul-smelling liquid fills the core area of the bulb (Figure 18). When harvesting, the tops of infected onions will pull off, leaving the rotting bulb still in the ground.

Management Options*:* Avoid overhead irrigation where the water source has been potentially contaminated with soft rot bacteria. Application of fixed copper products may be marginally effective in reducing spread. As with most bulb diseases, harvesting mature onions, care in handling, and storage in cool, dry areas will prevent post-harvest losses.

Figure 19. Yellow Bud Symptoms on an Onion. Photo: Ronald D. Gitaitis, University of Georgia, Bugwood.org.

Yellow Bud

Yellow bud (YB) is an emerging onion disease that has the potential to severely affect Vidalia onion production. This disease was first observed in Georgia in 2007 and has since been spreading throughout the Vidalia onion-growing area in Georgia. However, to the best of our knowledge, this disease has not been reported elsewhere. The causal agent is a gram-negative, rod-shaped, aerobic bacterium that possesses all the phenotypic characteristics of *Pseudomonas syringae.* The yellow bud bacterium is possibly a pathovar of *P. coronafaciens* (as it is host-specific).

Symptoms: Symptoms of yellow bud include intense chlorosis in emerging leaves and severe blight in the older leaves. In time, yellow bud leads to stand loss, reduced bulb size, and may create possible avenues of ingress for secondary, soft rot organisms. The disease has also been observed in onion seed beds; thus, infected transplants could be widely dispersed to areas throughout the Vidalia region or elsewhere. Yellow bud occurrence in seedbeds may be an indication that the pathogen could be seedborne. There is evidence that this pathogen can be seedborne and seed transmitted in onion seeds.

Management Options: Preventive application of fixed copper materials tank mixed with EBDC fungicides (Maneb, Mancozeb, Manzate, Dithane, Penncozeb, and others) may reduce the incidence and spread of this disease. This pathogen is also temperature sensitive, and in most cases, yellowing symptoms subside with increase in temperature (> 55 °C).

Viruses

Figure 20. Yellow Spot Virus.

Figure 21. Tomato Spotted Wilt Virus.

Iris Yellow Spot Virus (IYSV) and Tomato Spotted Wilt Virus (TSWV)

These viruses have recently been detected in onions, but it is unclear if either is or will become a major disease in onions. TSWV has been a major disease in other crops in Georgia for many years. IYSV is known to be pathogenic on onions, which has become a major disease in other onion-producing regions, particularly in the western U.S. and particularly on onion seed crops. IYSV is spread by onion thrips (*Thrips tabaci*), which are not generally found in Georgia. Recently, however, this virus has been detected in Tobacco thrips (*Frankliniella fusca*), which is widely distributed in Georgia.

These viruses can be detected in onions that are otherwise symptomless. These latent infections may never become a problem, or symptoms may develop when onions are stressed such as during cold weather, during and after transplanting, or some other stress condition. It is unknown, however, if this does occur.

Symptoms: There is not enough information available to clearly identify symptoms associated with these viral infections. Small necrotic spots with green tissue remaining in the center may be a symptom expression. This has not always been correlated with detection during laboratory screening.

Management Options: Since these viruses are spread by thrips, thrips control may help control infection. Typically, thrips control (see insect section) has been important during late winter and early spring, but with the detection of these viruses, growers should begin scouting onions in the fall and early winter for thrips, taking necessary action when they appear. Since stress may be a factor in symptom development, care should be taken to minimize stress. Proper fertilization, water, and control of other diseases may be important. Obviously, transplanting shock and cold weather are unavoidable, but it may be helpful to avoid transplanting onions just before colder temperatures. If cold weather is expected, it may be wise to delay transplanting until the cold has passed.

Onion Insects and Their Control

Since onions are a winter crop in southeast Georgia, insect problems are not as severe as they would be for spring, summer, or fall crops. Preventative measures and careful scouting can minimize or eliminate any potential problems.

Thrips are the primary insect pest of onions. Thrips have a single mandible used to pierce plant cells, saliva is then injected, and the material is then pumped up through a tubelike structure formed by the maxillary stylets. This “rasping” of the plant leaves a distinctive silvery or bronze scarring at feeding sites. Damaged leaves are more susceptible to subsequent disease infection, as well as being less efficient at photosynthesis. Thrips can vector viruses in onions, such as IYSV, and have been implicated in aiding the spread of center rot.

While thrips can appear in the fall, they are much more common in late winter and early spring as temperatures increase. Populations of thrips and the severity of this insect problem on onions can vary considerably from year to year. When considering direct damage to onions, careful scouting of plants should begin shortly after the beginning of the year. Special attention should be given to leaf folds and down in the “neck” of the plant. Thrips have a strong preference for these “tight” areas that provide protection and will congregate at these locations. Spraying for thrips should begin when an average of five thrips is present per plant. However, research has indicated that a single spray of an effective insecticide when there is one thrips per plant can reduce subsequent thrips populations and reduce the number of subsequent insecticide sprays. Spraying within two weeks of harvest for thrips control does not appear to provide any benefit in terms of yield even if the threshold is exceeded. Thrips reduce yields in onion by reducing bulb size, thus, once the bulb has reached full size, thrips damage is inconsequential to yield.

However, thrips may transmit some onion diseases, and control near harvest may affect bulb quality.

Insecticide resistance in thrips populations is an ever-present threat, and the different thrips species may respond differently to specific insecticides. Excessive use of insecticides or the use of ineffective insecticides only increases the presence of insecticide resistance. Thus, when sprays for thrips are made, they should only be made in response to thrips populations exceeding the threshold, and species identification should be made before insecticide selection, as different species may respond differently to specific insecticides. It is also important to keep track of which insecticides are currently effective.

There are three species of thrips that can be prevalent on onions in the Vidalia region: Western flower thrips (*Frankliniella occidentalis*) (Figure 22), Tobacco thrips (*Frankliniella fusca*) (Figure 23), and Onion thrips (*Thrips tabaci*) (Figure 24). Most years, the primary thrips present is the tobacco thrips, followed by the western flower thrips. Onion thrips was prevalent for a few years around 2007 and was responsible for a dramatic increase in the occurrence of IYSV; however, this occurrence was associated with the importation of onions and thrips from Peru. Growers adjusted their importation practices and largely eliminated this problem.

Tobacco thrips are easily separated by the dark coloring of adult females (almost black), while other species are generally straw colored, and identification requires examination of characteristics under magnification. Tobacco thrips can frequently be controlled with pyrethroid insecticides, which generally perform poorly against the other two species. Separating western flower thrips and onion thrips is done fairly easily, as onion thrips lack a row of four ***setae*** (hairs) on the front edge of the pronotum (segment immediately behind the head on the top of the insect, Figure 24). Other thrips species can be found on onions, and most appear similar to the western flower thrips, but historically are rare and have not reached pest status.

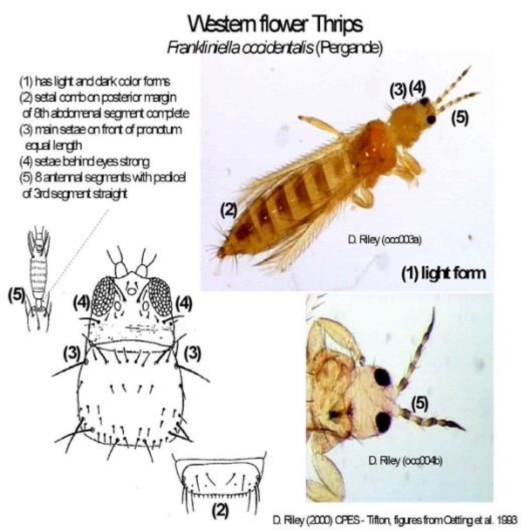

Figure 22. Western Flower Thrips.

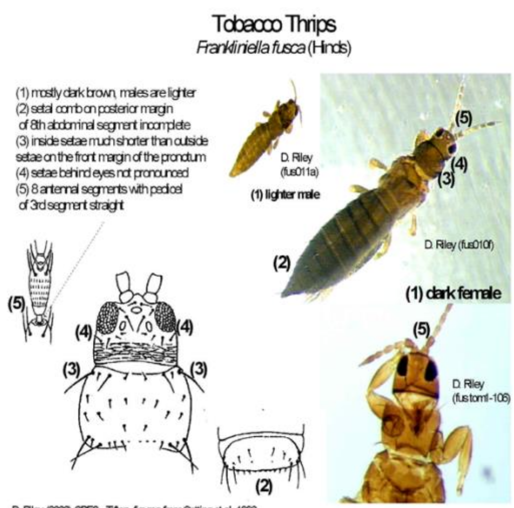

Figure 23. Tobacco Thrips.

Figure 24. Onion Thrips on the Left and Western Flower Thrips on the Right.

Figure 25. Onion Maggot on Onion Seedling. Photo: Whitney Cranshaw, Colorado State University, Bugwood.org.

Onion maggots (*Delia antiqua*) can be a severe pest in more northern states. The seed corn maggot (*D. platura*) is much more common in Georgia and generally does not cause as much damage as the onion maggot. The adults of both species are flies similar to, but smaller than, houseflies. Adults lay their eggs in the soil near seeds or seedlings, and the hatching larvae feed on the developing plants. Seedcorn maggots can reduce plant stands in seedbeds, as germinating seeds and small seedlings can be killed. Once plants are established, seedcorn maggots are not likely to cause plant mortality, but may be associated with dead and decaying plants, as these materials are attractive to the maggots, which will feed on most decaying plant material. It is also not uncommon to find large populations in fields shortly after severe frost damage. The frost damage results in an abundance of decaying organic matter in the fields, which is attractive to seed corn maggots. Seed corn maggot can be a problem late in the season as a contaminant in harvested bulbs. While they likely cause minimal damage to bulbs, the pupae can be tightly attached to and transported with bulbs, resulting in adult fly emergence in unwanted locations.

To avoid stand loss from seed corn maggots, fields should be plowed early to reduce the amount of fresh organic matter in the soil, and/or care should be taken to thoroughly treat the soil with an appropriate insecticide. Foliar applications can control adult flies and reduce in-season infestations.

Wireworms and other soil insects are frequently present in fields before planting. Wireworms are the larval stage of click beetles. There are several species of these insects, which may attack onions. Eggs are laid in the soil, and the larvae feed on below below-ground portions of plants. While some species have multiple generations in a year, others can live as larvae for 1 to 2 years before pupating and becoming adults. Wireworms and other soil insects tend to be more of a problem in fields that have been fallow (with abundant weed hosts) or in turf. Proper weed sanitation and field preparation several weeks before planting or transplanting can reduce problems with soil insects. Where soil insect problems are anticipated, preventative treatment with a pre-plant insecticide is recommended, as foliar applications provide little to no control.

Figure 26. Wireworm and Damage on Onion Seedling. Photo: Alton Sparks, Jr., University of Georgia, Bugwood.org.

Figure 27. Cutworm and Damaged Onion Seedling. Photo: Whitney Cranshaw, Colorado State University, Bugwood.org.

Cutworms are the larval stage of many species of moth in the Noctuidae family. These caterpillars generally feed at night and hide during daylight hours. Damage is generally detected as plants cut off near the soil line. Their nocturnal habits and cryptic coloration make them difficult to find, which is required for proper diagnosis of the problem. These pests are more easily detected by examining plants very late or very early in the day. Foliar applications can provide control of cutworms, and it is frequently recommended that these applications be applied late in the day, as the caterpillars are active at night.

Insecticide Recommendations for Insect Pests of Onions

Specific insecticide recommendations are not included in this publication as registrations and efficacy of products can change rapidly. For currently labeled and recommended insecticides for insect pests of onions, please refer to the current *Georgia Pest Management Handbook—Commercial Edition*.

Onion Weed Management

Managing weeds is critical for successful onion production as the crop lacks the ability to effectively compete against most of these pests. Weeds outcompete the crop for light, nutrients, water, and space. In addition to reducing harvestable bulbs through competition, weeds have been shown to interfere with and, at times, even eliminate harvest. Weeds can also harbor destructive insects and diseases that can severely damage the present or subsequent crop.

Weed species that commonly infest onions include both summer and winter annuals, with the more common species in a specific field influenced by planting time. It is more likely that summer annual weeds such as pigweeds, nutsedge, annual grasses, morningglory, purslane, and Florida pusley will infest early fall plantings. As plantings are delayed, summer annual weeds become less of a challenge as infestations of winter weeds, including cutleaf evening primrose, swinecress, henbit, Virginia pepperweed, shepherd's-purse, wild radish, and common chickweed become more common.

Currently, cutleaf evening primrose and wild radish (figures below) are the most challenging of all weeds to control in onion production as they are 1) extremely competitive, 2) infest nearly every agricultural field, and 3) are often impossible to control with herbicides after emergence. Fumigation can be effectively implemented to manage weeds in seedbed production, but this weed management approach is likely to be expensive for use in large-acre seeded production. Thus, growers generally transplant the crop, allowing for a better opportunity to control these weed species as transplant onions are tolerant to several effective herbicides.

Figure 28. Wild Radish.

Figure 29. Cutleaf Evening Primrose.

Methods of Weed Management

A diversified weed management approach integrating cultural, chemical, and mechanical control measures often achieves the most success. Also of critical importance is the need for crop rotation to break the cycle of continuous onion production in the same field year after year. Some fields in Georgia have been treated with pendimethalin (Prowl, others) and oxyfluorfen (Goal, others) for many years in a row. The over-dependence on these herbicides is leading to concern for herbicide resistance to these chemistries. Losing either herbicide to weed resistance could potentially devastate Georgia's onion industry.

Crop Rotation

Crop rotation aids in the management of most pests while also delaying the potential for herbicide resistance. Controlling certain broadleaf weeds or nutsedge species is very difficult to achieve in onions. Thus, rotating to a crop where these problematic weeds can be controlled more easily, more effectively, more economically, and with herbicide chemistry not used in onion is critical. Rotation to other crops, promoting the application of different herbicides on the same field in different years, is a key approach to mitigating the impact of herbicide resistance.

Hand-Weeding

Hand-weeding can be implemented to effectively control many weed species; an exception would be nutsedge. However, because of intense weed populations and continual emergence cycles in our region, the practice is rarely an economical stand-alone approach for management. When used as part of a systems approach, such as with an herbicide program, the practice can be strategically implemented to improve weed control, reduce the number of seeds being added into the weed-seed bank, facilitate a more effective harvest, increase yields, and delay the potential for herbicide resistance.

Weeding by hand must be conducted when both the crop and weeds are small in order to reduce crop damage, to allow for the use of mechanical tools such as hoes, and to minimize the number of labor hours needed for weed removal. Large weeds with extensive root systems will likely damage onion roots or foliage when removal is attempted.

Stale Seedbed

The stale seedbed technique employs a non-selective herbicide such as paraquat or glyphosate to kill emerged weeds before planting onions. In the stale seedbed method, the seedbed is prepared several weeks before planting. Weeds are allowed to emerge and are then killed by the non-selective herbicide. The crop is then planted at the appropriate time with minimal soil disturbance to prevent stimulation of weed germination. A second method of stale seedbed weed management that does not include the use of herbicides involves light/shallow cultivation of the desired area several times as weeds emerge before planting.

The stale seedbed approach would likely be beneficial for growers attempting seeded production. In contrast, the stale seedbed approach is often of little value in transplant production as long as the field is free of weeds at planting, and one implements a sound herbicide program.

Fumigation

Fumigation can provide substantial weed control, but it must be applied by trained personnel following strict guidelines, including completing a fumigant management plan. Metam sodium is the most commonly used fumigant applied, mostly for seedbed production. At the full use rate of metam sodium (Vapam HL at 75 GPA broadcast, other products are available), many broadleaf and grass weeds are effectively controlled while suppressing nutsedge species. However, large-seeded weeds with hard seed coats like morningglory are often not controlled. Appropriate soil conditions, including no soil clods, moisture at field capacity or slightly wetter, and soil free of debris, including plant material, is essential for an effective fumigation.

The use of overhead irrigation after applying the fumigant can serve as a barrier, keeping the fumigant in the soil for a longer period, thereby improving control. In general, the longer one keeps the fumigant in the soil, the better the weed control will be. Application through a pivot can also be very effective; many restrictions are required to use this application procedure; thus, one must study the label carefully.

One significant mistake often occurs when beds are freshened after fumigation and just before seeding. Avoid contaminating the treated zone with untreated soil through subsequent tillage. Untreated soil brought into the planting zone will lead to significant loss in fumigant effectiveness.

Plant back intervals delaying planting after fumigation must be followed to avoid crop injury. These intervals are influenced by product, rate, and application method. More details are available on labels or from your local Extension agent.

Herbicides

Planning your herbicide program: Soil characteristics (such as soil organic matter and texture), herbicide capabilities and limitations, herbicide application methods, and expected weed species should all be determined prior to selecting your herbicide program. Additionally, understanding herbicide carryover from previous crops is critical. Some herbicides used in crops rotated with onions pose a significant threat to onions, and these concerns must be addressed prior to planting. Always read labels for crop rotational restrictions.

Mapping: Knowing what weeds will be present in the onion field can greatly increase the potential for successful weed management. This is best accomplished by weed mapping. Survey fields and record on a field map the weed species present and their general population levels at harvest. Those species present at harvest will most likely be the predominant problem weeds next season. Additionally, by referring to weed maps over a period of years, one can detect shifts in weed populations and adjust herbicide programs to manage these weed shifts as they occur. Proper weed identification is necessary since weed species respond differently to various herbicides.

Monitoring: Fields should be monitored periodically to identify the need for postemergence herbicides, albeit options are quite limited in onion production. Even after herbicides are applied, monitoring should be continued to evaluate the success of the weed management program and to determine the need for additional control measures.

Herbicide Options In 2024

Preplant applications for dry bulb or green onions include paraquat and glyphosate (Table 8). Many weeds can be controlled with these herbicides; however, several weed species, such as cutleaf evening primrose and nutsedge, are often not effectively controlled by either product applied alone. For the more troubling weeds, the ideal herbicide burndown would be glyphosate, followed by paraquat 5 to 7 days later.

Preemergence herbicide options for seeded crop or plant bed of dry bulb and green onions: Historically, Dacthal was the only preemergence option labeled for use in seeded dry bulb and green onions. However, on August 6, 2024, the U.S. EPA issued an emergency order to stop use of Dacthal because of health risk concerns with the herbicide. Thus, Dacthal can no longer be used in any crop.

Preemergence weed control while applied post-transplant to dry bulb onions: For transplant dry bulb onions only, the use of Goal and Prowl (numerous brands of each herbicide) is extremely effective and is at least, in part, the reason onions are transplanted as compared to being seeded in Georgia (Table 8). The level of weed control for most weeds, exception being nutsedge, is exceptional. Prowl provides residual control of small-seeded grass and broadleaf weeds, while Goal provides residual control of many of the most problematic weeds infesting onions, such as pigweed, primrose, and wild radish.

Postemergence herbicide options for green and bulb onions include Dual Magnum, Outlook, Poast, and Prowl. Poast is an excellent tool to control emerged annual grass weeds but does not provide residual control. In contrast, Dual Magnum, Outlook, and Prowl will provide residual control of select small-seeded broadleaf and grass weeds if activated promptly, but these products do not control emerged weeds. Proper application timings for Dual Magnum, Outlook, and Prowl are critical, especially in seeded production (Table 8).

Additional postemergence tools are available for dry bulb onions and include Goal, clethodim (Select, others), and Fusilade DX. Select and Fusilade DX offer control of emerged grass species. In general, clethodim is more effective on annual grasses, while control of perennial grasses such as bermudagrass is expected to be similar. Goal and Prowl are the backbone herbicides for all effective dry bulb onion production systems.

Weed Management Systems

Seedbed: The most effective program for seedbed production begins with a fumigant application of metam sodium. Utilize glyphosate 3 days before seeding to control weeds that have escaped the fumigant application or emerged afterwards, and/or apply paraquat any time before onion emergence. No weeds must emerge when planting. With the loss of Dacthal as the only at-plant residual herbicide, the fumigant application must perform exceptionally well.

Grass control herbicides are available to be applied topically to the crop and weeds for control. Prowl (applied after the 2-leaf stage of onion), Dual Magnum (applied after the 4-leaf stage of onion), and Outlook (applied after the 2-leaf stage of onion) can be added into the system for residual control.

Dry bulb transplant production: An ideal program would include freshly tilling the ground to remove all weeds, followed immediately by transplanting. Within 24 hr of planting, irrigate lightly to seal the soil around the transplant root ball. After that first light irrigation and within 2 days of planting, Prowl + Goal should be applied broadcast over the top of transplants. A second irrigation within 24 hr of applying herbicides is critical for activation.

Dual Magnum or Outlook can be added to the program for additional residual control and should be applied approximately 4–8 weeks after planting when reaching the appropriate onion stage of growth, avoiding crop stunting (Table 8).

Dry Bulb Seeded Production: Weed control in seeded onion production is among the most challenging of any crop grown in Georgia. No herbicide program is effective in fields containing wild radish or cutleaf evening primrose. The likelihood of success would depend on finding fields free of problematic weeds. With the loss of Dacthal in 2024, the potential to produce a seeded onion crop is even more unlikely.

Metam sodium as a preplant fumigant and sequential postemergence applications of Prowl, Goal, Outlook, and Dual Magnum during their appropriate application windows offer the best chance for success (Table 8). Even with applications made on bi-weekly intervals, the system fails to control troublesome weeds throughout the crop season in research.

In 2024, for the first-time research documented nearly complete weed control in a seeded onion production system. This task was not achieved with herbicides or tillage but rather using the LaserWeeder. At harvest, over 90% control of all weeds were observed in the experiment with onions having diameters and weights at least 39 and 68%, respectively, greater than the herbicide program.

Figure 30. LaserWeeder.

Table 8. Herbicide Options for Onions.

Weed	Product formulation	Rate/acre broadcast		Remarks and precautions
		Product rate	Active Ingredient (lb)	
Onions (Dry Bulb and Green): Preplant				
Suppression or control of most annual grasses and broadleaf weeds. Full rate provides about 80% control of nutsedge.	*metam sodium* Vapam HL 42%	45–75 gal	19–31.5	Rates are dependent on soil type and weeds present. Apply when soil moisture is near field capacity (60%–80%). Apply through soil injection preferably shanking the product to a depth of 4 in. using knives spaced 4 in. apart; follow immediately with a bed shaper, roller, or other method to smooth and compact the soil surface. If irrigation is available, irrigate with at least 0.25 in. and/or cover with tarp immediately. If using irrigation to seal soil, sequential irrigations are needed for the first week but do not overwater as this may reduce pest control. May apply through drip irrigation. May also apply preplant through center pivot but must follow serious buffer restrictions noted on the label. Plant back interval is often 14–21 days and can be 30 days in some environments. **Labels require buffer restrictions, additional worker protection safety procedures, and a fumigant management plan; study this label closely which can be found at www.cdms.net.**
Contact kill of green foliage; annual weeds < 3 in.	*paraquat* 3SL 2SL	 1.7–2.7 pt 2.5–4 pt	0.64–1	**EPA has restricted the use of *paraquat* to certified applicators ONLY and applicators must take a specialized training before use**. For seeded production, apply preplant or preemergence prior to crop emergence. For transplant production, apply at least 24 hr before planting. Add 1 qt NIS or 1 gallon COC per 100 gallon spray mix. For stale seedbed, apply glyphosate 5–7 days prior to planting; follow with paraquat 1 day prior to planting.

Most emerged weeds except for resistant pigweed, primrose, spiderwort, and large morningglory.	*glyphosate* 4SL (3 lb ae) 5.5SL (4.5 lb ae) 5.88SL (4.88 lb ae)	32—96 fl oz 22—66 fl oz 21—60 fl oz	0.75–1.5 lb ae	**Bareground transplants:** Suggest applying no more than 1.13 lb ae/A in a single application. Also, if not tilling, suggest irrigating (rain) 0.5 in. and wait at least 7 days between application and transplanting. **Bareground seeding:** Apply before planting, suggest at least a 3-day interval and irrigation between application and planting. Apply ≤ 1.13 lb ae for annual weeds and higher rates for perennial weeds, see label. *For nutsedge, purslane, or ryegrass:* Apply *glyphosate* and follow with *paraquat* 5—7 days later if labels allow.
Onions (Dry Bulb and Green): Postemergence				
Residual control of pigweed, purslane, spiderwort, and grasses.	*S-metolachlor* Dual Magnum 7.62EC	8—16 fl oz	0.47-0.96	**A Section 24(c) Georgia Local Need Label** must be obtained at **syngenta-us.com/ labels/indemnified-label-login**. **Seeded (green or dry bulb):** Do not apply before the 4-leaf stage. From the 4—6-leaf stage apply 8 oz/A; rate can be increased to 12 oz/A after the 6-leaf stage. **Transplant (dry bulb only):** Transplant, irrigate to seal soil around the root ball, and then apply within 48 hr of planting. Rates of 12—16 fl oz are often in order. If needed, a second application at the same rates can be made 21 or more days after the first application.
Residual control of pigweed, purslane, spiderwort, and grasses.	*dimethenamid* Outlook 6 L	10—12 fl oz	0.47—0.56	***Seeded:*** Label allows application after 2-leaf, but injury is likely; thus, consider applications between 3–6-leaf, applying no more than 10 oz/A and a rate of 12 oz/A only after the 6-leaf stage. Sequential applications can be made 14 days apart but one must not exceed a total of 21 oz/A for the season. ***For transplants*:** transplant into weed-free fields, irrigate to seal soil around the root ball, and then apply within 48 hr followed by an activating irrigation or alternatively apply postemergence at least 30 days prior to harvest.
Residual control of annual grasses and small-seeded broadleaf weeds	*pendimethalin* Prowl 3.3 EC Prowl H_2O 3.8 AS	1.8—2.4 pt 1.5—2 pt	0.74—1 0.71—0.95	**DRY BULB:** **Seeded:** Apply when onions have 2—9 true leaves but prior to weed emergence. **Transplants:** Apply to onions after soil has settled (watered) around transplants. Activate within 24 hr, prefer 8 hr. **GREEN ONION (Prowl H20 Label):**

				Seeded: Apply when onions have 2—3 true leaves but prior to weed emergence and at least 30 days before harvest.
Actively growing annual grasses.	*sethoxydim* Poast 1.5EC	1—1.5 pt	0.19—0.3	Label requires addition of 1 qt of COC/A. Adding crop oil increases injury potential. Do not apply more than 4.5 pt/A/season. Do not mix with other pesticides and do not apply within 5 days of a broadleaf herbicides or cultivation.
Onions (Dry Bulb Only): Postemergence to Crop; Pre to Weeds				
Excellent residual control of henbit, purslane, pigweed, primrose, radish smartweed, and many others; can control a few small, emerged weeds.	*oxyfluorfen* Goal 2 XL 2EC Galigan 2E Goaltender 4F Galigan $H_2$0 4F	3—32 fl oz 3—32 fl oz 1.5-16 fl oz 1.5—16 fl oz	0.05-0.5	**Seeded dry bulb onions:** Apply 3—8 oz/A of Goal 2XL (1.5—4 oz/A of Goaltender) in a minimum of 40 GPA and with no less than 20 psi. Apply when onions have at least 3 true leaves, when weeds are ½ in. or smaller, and when conditions are not cool, wet, and/or cloudy. Use lower rates on younger onions with 3—4 oz/A of Goal 2XL ideal for onion in the 3—4-leaf stage. Sequential applications may be made but do not exceed 2 pt/A/season of Goal 2 XL (1 pt/A for Goaltender). *The rates discussed here are lower than suggested on the label and are provided to help avoid severe injury; obviously less weed control is expected with lower rates.* **Transplanted onions**: Suggest making a single application using up to 2 pt/A of Goal 2XL (1 pt/A of Goaltender) within 2 days of transplanting but after irrigating to seal soil around root ball. **Waiting longer than 2 days after planting will likely increase injury and reduce weed control.** Do not exceed 2 pt/A of Goal 2XL (1 pt/A of Goaltender) per crop season. A tank-mix with Prowl has shown excellent season long control. **NOTE:** For seeded onion, apply *oxyflurofen* only with water; no adjuvants, pesticides, or fertilizers.
Actively growing annual and perennial grasses. Clethodim is generally more effective on annual grasses.	*clethodim* Select 2 EC SelectMax 0.97 EC TapOut 0.97 EC	6—16 fl oz 9—32 fl oz 9—32 fl oz	0.09—0.25 0.07—0.25 0.07—0.25	**Section 24(c) Georgia Local Need Label** allows an application of Select Max without the addition of an adjuvant; applying Select Max at 9—10 fl oz/A when grasses are less than 3 in. (goosegrass < 1.5") is the best option for control with lowest injury potential. The addition of NIS with Select Max at 1 pt/100 gal spray mix is recommended for large grasses and goosegrass. For Select, add 1 gal COC/100 gallon spray mix according to the label; injury is more likely with crop oil. Do not mix with other pesticides. Application of a broadleaf herbicide or cultivation within 5 days of *clethodim* may result in reduced grass control. For Select Max, repeat applications may be made as long as they are at least 14 days apart; do not exceed a seasonal total of 64 oz/A.

	fluazifop-P-butyl Fusilade DX 2 EC	6–16 fl oz	0.1–0.25	Label requires addition of 1 gal COC or 1 qt NIS/100 gal spray mix. Adding crop oil increases injury potential. Do not mix with other pesticides. Do not apply more than 48 oz/A/season.
Onions (Dry Bulb Only): Row Middle Hooded Sprays				
Most emerged weeds except for resistant pigweed, primrose, spiderwort, and large morningglory.	*glyphosate* 4SL (3 lb ae) 5.5SL (4.5 lb ae) 5.88SL (4.88 lb ae)	32–96 fl oz 22–64 fl oz 21–60 fl oz	0.75–2.25 lb ae	Label allows a hooded spray or as a wiper application in row middles. To avoid severe injury, do not allow herbicide to contact any part of the crop including exposed roots. Apply ≤ 1.13 lb ae for annual weeds and higher rates for perennial weeds, see label.
Morningglory, spiderwort, and pigweed < 1 in.	*carfentrazone* Aim 2 EC	0–5-2 fl oz	0.008–0.031	Apply as a hooded spray in row middles. Do not allow herbicide to contact the crop. Apply to weeds less than 2 in.; pigweed less than 1in. Add 1–2 gallons COC/100 gal of spray mix. Expect some leaf speckling from drift.

Harvesting, Curing, and Storage

Bulb quality is the most important factor when producing a marketable product. To ensure maximum quality, onions should be artificially cured. Artificial curing allows the grower to have better control over the curing process. During years when excessive rains and unfavorable drying conditions occur in the field, artificial curing is an important step to ensure onions of high quality.

Harvesting

Onions should be harvested at optimum maturity. Maturity is best determined by pinching the neck of the growing onion. Necks of immature onions are stiff, whereas necks of mature onions are soft and limber. Early varieties are strongly daylength sensitive and thus are more likely to break over at the neck early and uniformly. These onions can be left in the field in this condition for up to a week without detriment under most conditions (no heavy rains). Later maturing varieties may show 20%–50% of their tops broken over at the neck for optimum maturity. In some years, this may not occur because the onions have developed a thicker neck. This is usually associated with mild winter weather. Simply observing the percentage of tops having fallen over is not a true indication of maturity, since the tops can be knocked over by strong winds, rain, or become limp from lack of moisture. Onions should be carefully examined for softness in the neck and large bulb size to indicate the time to harvest. Late varieties are highly susceptible to warm-weather bacterial diseases and may require harvest before optimum maturity to prevent widespread infection with bacterial diseases.

Onions should be undercut with a rotating bar or fixed blade when they are mature and the necks are soft and limber. The blade or rotating bar should operate at approximately 1 in. below the bulb, so as not to damage its base. A rope is often dragged across the top of the onions at the same time to roll the onions out of the ground and expose the roots. Every effort should be made to prevent excessive bulb exposure to the sun, which will cause the onion to blister; therefore, onions should be gathered within a few days of undercutting. If light rain occurs during field drying, the onion beds should be undercut a second time. This will break soil that has been reattached to the bulb.

After onions have field dried for 3 to 5 days under sunny, dry conditions, the roots and tops of the onions should be removed. Tops are cut at approximately 1.5 to 2 in. above the bulb and roots are cut off completely. Extra short necks increase the likelihood of disease infection. During clipping, care should be taken to prevent injury to the bulbs with the shears and by dropping the bulbs onto hard surfaces such as the bottom of buckets and other onions. Hand-harvested bulbs can be placed into burlap or mesh bags in the field and transported by truck to packing sheds. Another method has them placed in large bin boxes that are moved by forklifts to trucks for transport to packing sheds. Onions should always be carefully handled to avoid external and internal damage, especially when loading onto the hard surface of truck bodies. Walking and standing on bags of onions should be avoided. The bulbs should be placed in bins or boxes with at least 6% vent space. The bins should be immediately placed on a drying system. Remaining roots will shrivel during curing and will be knocked off on the packing line. Necks should dry during curing and fold over when handled.

Research and field demonstrations indicate that sweet onions can be harvested using a mechanical harvester. Sweet onions are undercut as usual in the hand harvest production system. They are allowed to field dry for 3 to 5 days. The harvester lifts the onions onto an elevator chain, and the soil is separated from the onions. When the onions have reached the top, a fan pulls the leaves into a vertical plane, and the leaves are cut off. Tops are deposited onto the ground, and bulbs are conveyed into a trailer or bin. The onions are transported to the packing facility and passed through a mechanical topping machine, which removes the remainder of the tops left by the harvester. Neck length is approximately 1 to 1.5 in. After leaving the topping machine, the onions are graded for quality and size and placed in mechanical dryers for curing. Storage studies indicate that shelf life is the same for machine-harvested and hand-harvested mature onions.

Onion Curing

Onions are cured to extend their shelf life. An onion bulb is a series of concentric swollen leaves still attached to a short stem or base. These are surrounded by scales, which are dried leaves. Curing of onion bulbs serves several functions. First, it dries the outer two to four scales, providing mechanical protection. It dries those roots remaining attached to the bulb following undercutting and the neck left attached to the crown following topping, deterring disease infection. Lastly, curing encourages dehydration and the sealing of wounds that may have resulted during bulb growth or mechanical damage. The term “curing” rather than “drying” of onions is preferred because the removal of moisture is limited to the parts mentioned, while protecting the high moisture content of the flesh inside the bulb. This differs from “drying” other commodities, such as peanuts or grain, where moisture is removed from inside the seed or kernel. Onion bulbs consist of a high proportion of water (approximately 90%), and desiccation of the bulbs must be avoided.

Moisture is removed from the skin, roots, and stem of onion bulbs by dry air blown over them. The onion skin dries and becomes uniform in color, exhibiting a brittle texture. The roots shatter or break off easily when touched. The stem area should shrink in size and be dried to the surface of the bulb. It should not slide back and forth when squeezed between the thumb and forefinger. Once the onion has cured properly, the outer leaf scales will help retain internal moisture and protect the onion during shipment.

The curing of sweet onions with forced air involves the following parameters. The air temperature should be maintained between 97 to 100 °F. The airflow should be 365 to 1,030 CFM/ton of sweet onions. Linear air velocity should be 15 to 21 ft/min through the stack of onions. The less airflow capacity and the poorer the ventilation of the load, the longer it will take to cure the onions. Relative humidity should be maintained at approximately 50% to 65%. There are two types of artificial curing systems being used: batch and re-circulating forced air.

Batch curing is the most common type of curing system, consisting of the heating of outside air and forcing it through a stack of onions, with the air exiting to the outside environment. It is difficult to control humidity with this system because the conditions of the outside air vary. For batch curing with an airflow rate of 780 CFM/ton of onions with a 35 °F rise in air temperature, the heater should have the capacity of 30,030 BTU/ per ton of onions. To allow air movement away from the onions, an air space of 25 ft above the top bins is required.

Re-circulating forced air curing involves recirculating the air within a chamber that passes around the onions. Stacking the onion bins in two rows to form a tunnel and pulling air through is also called forced air curing. Temperature and relative humidity are much easier to maintain, giving the operator more control over the curing process. Air may either be forced or pulled through the onions. Moisture-saturated air exits the facility by vents and is replaced by incoming, dry air. The supplemental heat required for re-circulating air curing is 3,500 BTU/ hr per ton of onions. These calculations are based on a minimum 65 °F environmental temperature and 99 °F curing chamber temperature.

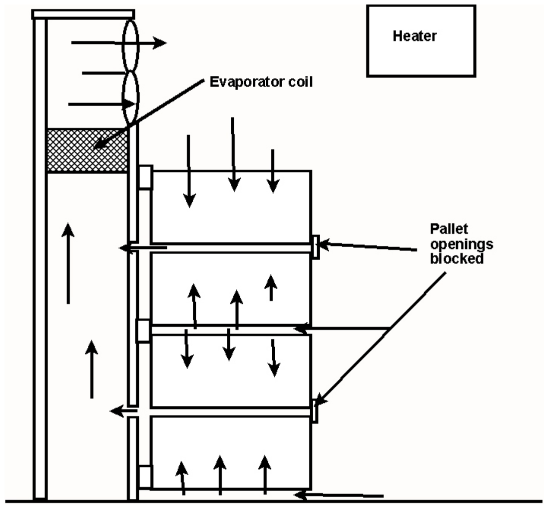

Figure 31. Onion Curing.

Air movement is very important to curing onions. The air must move around the onions and not escape through cracks in between bins or boxes. The forklift space below bins and handle areas of boxes should be closed off with strips of plastic or canvas to stop airflow through these areas. When air is being pushed through the containers, a more rigid material like wooden panels should be used. The fan framing should be placed tightly against the containers to eliminate any loss or escape of air (Figure 31).

Onions are generally cured for 24–48 hr before final grading and packing. This may vary depending on the condition of the onions. Onions should be sorted and inspected immediately following curing before shipping or storage. If the onions are left unattended for more than 1 week, they should be inspected again since diseased onions are likely to infect other onions during shipping or storage. Fresh market onions should be in the hands of the consumer within 4 weeks of harvest. Onions destined for cold storage should be sampled and analyzed for disease before storage to remove infected bulbs. There is no point in storing onions that are already infected.

In some cases, onions may be cured solely in the field. Under favorable weather conditions, onions can be left in the field for 5–7 days after undercutting. Care should be exercised with this process since onions are subject to sun damage if left in the field too long.

It is very important to monitor the curing process to avoid over-drying or inadequate drying. Under-curing can leave the onions prone to diseases during storage, while over-curing can lead to excessive dehydration and loss of weight. The ideal outcome is a balance where the outer skins are dry and protective, but the interior remains firm and retains its high-quality and texture. Once properly cured, the onions should be promptly moved to a cold storage facility to maintain quality, reduce sprouting, and prolong shelf life.

Late-maturing and late-harvested onions can be more prone to late-season warm-weather bacterial diseases such as sour skin and slippery skin. Care should be exercised not to harvest such onions, and they should not be co-mingled with uninfected onions, particularly during curing. The heating process of curing will rapidly spread the bacteria throughout all the onions.

The storage method chosen is dictated by the market window being targeted—i.e., fresh blown air, air-conditioned, cold, or controlled atmosphere. The method of storage influences the rate of decay but will not stop it. Onions going onto the market following the fresh market window may be kept in cold storage but should be placed into cold storage within 1 week of being undercut. Any delay encourages disease growth. Two types of damage occur during the handling of onions. Surface injuries are made in the field by cuts, punctures, and wounds with snips and fingernails. Bruising injuries are caused by impact shocks or vibration damage in the field or at the packing shed. Surface injuries are obvious, but bruising is more subtle, often not showing up until after the onions leave the shed. It is important to recognize the significance of bruising as it relates to onion quality and shelf life. Bruising causes superficial cracks in the outer scales of onions, allowing bacteria and mold organisms to penetrate and break down the internal tissues, resulting in decay. Evidence of poor handling is seen as bacterial soft rot and various mold rots at the terminal or retail markets.

Better supervision of workers' activities during harvesting and subsequent loading operations usually reduces bruise damage in sweet onions. Careless topping or cutting of roots leads to surface wounds and decay. Shock damage occurs when bags are thrown onto flatbed trucks, and pressure bruising results when workers stand on lower bags to load or remove higher bags. Bruise damage is most serious at the packing shed, occurring as individual onions move across grading equipment. Product damage can be reduced if equipment is designed and installed properly. Damage also occurs during unloading. Workers characteristically slam burlap bags onto wooden or metal surfaces during onion unloading. The onion's weight multiplied by this velocity equals a substantial damaging force, so damage increases the speed at which onions fall. Padding these areas will reduce impact injury, which results in less bruising. Unloading is the first of many ways onions receive shocks on a packing line. Based on preliminary work done to pinpoint potential damage sites, there are at least eight stages in a typical line that inflict onion bruising. A simple investment in foam padding or insulated carpeting for these potential damage points can increase the pack-out yield. It is important to mention that padding is often difficult to clean and can harbor debris that will allow for pathogens to infest the area and potentially the onions that encounter it.

For the following recommendations to work, onions must first be in sound condition at harvest. Bulbs with internal decay cannot be suitably cured and can cause decay of adjacent bulbs during curing and storing.

Onions are graded and put into 3-, 5-, 10-, 25-, 40-, or 50-lb bags or boxes. Grading consists of sizing and removing rotten, damaged, or off-type onions. Onions can be sold immediately or stacked in a dry area with good air circulation. Early short-day onions do not store well and should be moved to the market within a few days of harvest.

To improve storability:

1. Harvest only healthy, mature onions.

2. Do not over-fertilize onions.
3. Withhold nitrogen fertilization 30 to 45 days before harvesting and irrigation 1 to 2 weeks before harvesting.
4. Harvest and handle onions carefully to avoid damage.

Do not hold onions any longer than necessary. Market them as soon as possible. Vidalia onions are required to be inspected by U.S. Department of Agriculture (USDA) inspectors to use the Vidalia name. Vidalia onions are graded into three grades: U.S. No. 1, U.S. No. 2, and U.S. Combination grade. They are also graded into size classes (Table 9). For more complete information on grading 'Granex' onions, view the publication *Bermuda-Granex-Grano Type Onions Grades and Standards* from the USDA (https://www.ams.usda.gov/grades-standards/bermuda-granex-grano-type-onions-grades-and-standards). The USDA grade standards list a "small" (1–2.25 in.) and "pre-packer" (1.75–3 in.) grade size, but these are never marketed as Vidalia onions.

Table 9. USDA Size Grades for 'Bermuda', 'Granex', and 'Grano' Type Onions.

Grade size	Minimum diameter (in.)	Maximum diameter (in.)
Medium	2	3.25
Large or jumbo	3	No requirement
Colossal	3.75	No requirement

Precooling of Short-Day Onions

Precooling is an important step in postharvest handling of onions aimed at quickly removing field heat to slow respiration, water loss, and microbial growth, thereby preserving quality and extending shelf life. It can be crucial for sweet, high-water-content onions like Vidalia, which are prone to sprouting and decay if not cooled promptly. Precooling ensures a uniform temperature reduction, preventing water condensation that can lead to diseases.

Effective precooling, typically achieved with methods like forced air cooling, prepares onions for long-term cold storage and transport, maintaining quality. This step helps reduce spoilage and shrinkage, ensuring consistent product quality and economic returns for commercial producers.

Forced air cooling is a highly effective postharvest precooling method used to rapidly cool down produce items to their optimal storage temperature. In forced air cooling, cool air is circulated through the stored onions by creating a pressure differential between the two sides of a pallet or storage bin. The onions should be placed in vented crates or bins, and a fan is used to pull cool air through them, allowing for rapid and uniform cooling. This method is much more efficient than passive air cooling (room cooling), where onions are left to cool gradually in a cold room.

The temperature for forced air cooling should typically be set between 32 °F and 34 °F to effectively bring the onions down to their ideal storage temperature. The cooling rate is influenced by factors such as airflow velocity, onion size, and initial field temperature. By rapidly removing field heat, forced air cooling minimizes water loss and reduces the likelihood of quality deterioration. However, it is important to manage the relative humidity during the process and avoid prolonged precooling periods, which cause excessive dehydration manifested as shriveling and weight loss. Relative humidity levels around 65% to 70% are generally recommended for sweet onions to maintain quality without promoting rot.

Forced air cooling also plays a role in the overall postharvest handling strategy, as it can be combined with curing for optimal results. For instance, onions can be precooled after curing to ensure that any remaining field heat is dissipated before they are placed in cold storage.

Cold Storage of Short-Day Onions

Vidalia onions are characterized by higher water content and softer skins compared to long-day varieties; thus, they are more susceptible to quality deterioration during storage. To optimize storage conditions, maintain a temperature range of 32 °F to 34 °F and relative humidity of 65% to 70%. This cold environment slows down the metabolic processes that lead to sprouting and microbial decay while minimizing water loss. However, very high humidity levels should be avoided to prevent fungal growth, particularly neck rot, which is common under higher moisture conditions. It’s also vital to ensure adequate ventilation and air flow to maintain uniform temperature and humidity throughout the storage space and reduce the risk of condensation on the onion surfaces.

Onions that are not marketed immediately can be stored for short periods under refrigeration (34 °F, up to 1 month). Refrigeration will minimize losses in onions that are held for short periods before moving onto retail markets. Care should be exercised when onions are first removed from refrigerated storage. Moisture can condense on the cold onion surfaces, promoting the growth of sooty mold. This can be minimized by immediately placing cold onions under blowing air to prevent condensation.

Onions in cold storage will continue to respire, and high levels of carbon dioxide can rapidly build up under such conditions. As CO_2 levels approach 10% a physiological condition will develop in onions called translucent scale. This will appear as water-soaked rings, but unlike water soaking due to freeze injury, translucent scale usually appears among interior rings rather than at the surface as in freeze injury. Rooms used for refrigerated storage should be ventilated to prevent such a buildup of CO_2. This is particularly important in rooms that are not being accessed regularly, as would occur with rooms where onions are being regularly removed for shipment. Constantly entering the room can be enough ventilation to prevent translucent scale.

Shipping and retail sales: Onions that have been held for an extended period, either in cold storage or CA storage, will have less shelf life after removal from storage. Research has shown that CA-stored onions can lose 30% of their marketability in just 2 weeks under ambient conditions. Onions are usually displayed at retail under ambient conditions, but retailers and consumers should be counseled to store onions under refrigeration whenever possible to prevent losses. Point-of-sale displays that educate consumers about the importance of refrigerated storage should be considered by retailers.

Food Safety Practices

Multiple outbreaks of foodborne illness associated with dry bulb onions have occurred over the past several years, both in imported and domestically produced onions. The primary causative agent in these outbreaks has been *Salmonella enterica*, a bacterial pathogen that is one of the leading causes of foodborne illness in the United States. In 2023, 80 people were sickened in an outbreak caused by contaminated diced onions, which ultimately resulted in 1 fatality (Centers for Disease Control and Prevention [CDC], 2023). An outbreak in 2021 involving whole red, white, and yellow onions sickened 1,040 people with salmonellosis (CDC, 2022). And in 2020, a *Salmonella* outbreak linked to domestically grown red onions sickened 1,127 individuals, at the time making it the third largest U.S. *Salmonella* outbreak in the past 30 years (McCormic et al., 2022). To reduce the likelihood of such outbreaks occurring with their own products, growers and packers should use Good Agricultural Practices (GAPs) throughout the production process to reduce potential routes of contamination. For onion production, this includes managing soil amendments to reduce risks, using high quality water for irrigation, sanitation, and other uses, excluding onions that are damaged or contacted by animals and animal feces, ensuring equipment and surfaces are cleaned and sanitized regularly, and other practices intended to reduce pathogen growth in the production and handling environment, as well as potential contamination to the onion surface.

Growers of onions (and other produce, reference 12 CFR § 112.1(b) intended for the fresh market may be required to comply with the requirements outlined in the Food Safety Modernization Act's Produce Safety Rule (PSR; 21 CFR § 112). Farms that sell more than $25,000/year of produce in the previous 3-year period (adjusted for inflation to the 2011 baseline value) and do not meet any of the exemption criteria (21 CFR § 112.5) is considered a "covered farm" and may be subject to inspection by the Food and Drug Administration (FDA) or the state department of agriculture. These covered farms are required to have at least one supervisor trained in an FDA-approved curriculum (currently the Produce Safety Alliance Grower Training), which is offered in Georgia by the Georgia Department of Agriculture Produce Safety Team or the UGA Department of Food Science and Technology. This 1-day training covers PSR requirements to sell fresh produce and as well as recordkeeping practices to demonstrate compliance with the regulation.

Field Sanitation Program

Raw product safety: Ensuring fresh onion safety begins with preventing hazard introduction in the field. Foodborne pathogens such as *Salmonella* and *Escherichia coli* can be present in animal feces, which can contaminate soil and water sources. Low levels of pathogens like *Listeria monocytogenes* can be transported from production soils to curing, packing, or storage areas, where they can grow to large numbers on equipment surfaces and result in cross-contamination to the onion surface.

land use history: Grazing animals on or near cropland can introduce foodborne pathogenic bacteria to the soil, which can be harmful to humans. Growers should ensure that land has not recently been used for animal husbandry, and if using recently converted land, should adhere to the National Organic Program (NOP) requirement of a 120-day (90 days for commodities whose edible portion does not directly contact the ground) interval between application of uncomposted animal manure and onion harvest (7 CFR § 205.203(c)(1)(ii)). Land for onion production should ideally not be close to concentrated animal production areas, including areas that are subject to water runoff from animal agriculture. Growers should assess their production area for potential hazards before the start of the growing season and, when possible, implement practices to protect their fields. This may include removing animals from adjacent areas or restricting access to irrigation water sources. Fields that are likely to receive runoff may require regrading or construction of other barriers to divert water.

Soil amendments and fertilizer use: Nutrient sources and other materials added to production soils can be a source of foodborne pathogens, especially if they contain biological soil amendments of animal origin (BSAAO) that have not been composted or similarly treated, such as raw manure. When feasible, manures and other BSAAO should be composted or processed using a scientifically validated process to destroy foodborne pathogens. For instance, the FDA considers aerated static composting as a validated method when the pile reaches 131 °F for 3 consecutive days (21 CFR § 112.54(b)(1)). For turned piles, a minimum temperature of 131 °F must be achieved for 15 days, and the pile must be turned a minimum of five times (21 CFR § 112.54(b)(2)). Other validated methods may also be used if they achieve the microbial standards for pathogens provided in 21 CFR § 112.55. When treatment of a BSAAO is not possible, the NOP 90-120-day rule should be applied, with 120 days between incorporation of the untreated BSAAO into the soil and onion harvest (7 CFR § 205.203(c)(1)(ii)).

Preharvest water (e.g., irrigation, fertigation, pesticide application): All water used for irrigation or other instances where contact with the edible portion is likely should be examined for potential contamination. Surface water (e.g., canal, lake, or pond) can become contaminated by foodborne pathogens via domestic animal access, wildlife, runoff, leaking septic systems, and other sources. Groundwater is less likely to harbor human pathogens, but contamination of the aquifer or improper construction of the well itself may result in contamination. Farms that are covered by the PSR must conduct an annual agricultural water assessment when water is likely to contact produce. This includes examining the water source, the distribution system, and examining factors such as application method, crop characteristics, environmental conditions, and other factors that may impact the microbial safety of that water before it is used on fresh produce. Microbial testing for generic *E. coli*, an indicator of fecal contamination, may be a useful tool when conducting the agricultural water assessment.

Harvesting and handling: Harvesting equipment can spread foodborne pathogens and should be cleaned if contamination is suspected. Mechanical harvesting can result in onion damage, which may facilitate microbial contamination of the onion interior. If workers are used for hand harvesting or other activities involving direct onion contact, workers should practice good handwashing practices. Disposable gloves may be used but should be replaced regularly throughout the day, including when they may become contaminated. Gloves are never a replacement for proper handwashing activities. Knives and any other hand tools should be collected at the end of the production day and cleaned and sanitized to prevent cross-contamination. At any time when equipment is moved between farms or harvesting locations, harvesting tools and equipment should be cleaned and sanitized to avoid cross-contamination.

Postharvest water: Water used for cleaning and sanitation of food contact surfaces should be free of detectable generic *E. coli*. While onion processing facilities use less water than many produce facilities, water is still regularly used for cleaning and sanitation, as well as handwashing and must not contain *E. coli*. Because of this need for high-quality water, most farms rely on tested groundwater or municipal water.

Bathroom and handwashing facilities: Bathroom facilities close to the field should be readily available to workers. These may be portable stations but should be regularly serviced and maintained to ensure they do not pose a contamination risk. Portable bathroom stations should also be in an area where they are not likely to tip over and spill their contents into the field, or an area where runoff into the field is likely. They should also be readily accessible to encourage workers to use them.

Handwashing stations must be provided, and should contain clean water, soap, disposable paper towels, a water catchment container, and a trash receptacle. Stations may be relatively simple and constructed from a water cooler holding clean water and a 5-gallon bucket to catch spent water.

Postharvest practices: All surfaces contacting the onion bulbs (food contact surfaces) should be regularly cleaned and sanitized to remove dirt and foodborne pathogens that may accumulate on equipment. This includes harvest bins, conveyers, curing racks, brushes, and other surfaces likely to contact the bulbs. To do this, dirt must first be removed from the food contact surface (this step is called cleaning). This can be done by brushing dirt off when dry cleaning is necessary or may involve soap and water when moisture is acceptable. After dirt is removed, a sanitizer such as sodium hypochlorite or peroxyacetic acid may be applied to the surface to reduce the number of remaining foodborne pathogens (this is the sanitizing step). Concentrations and contact times for food contact surfaces will be indicated on the produce label and must be followed. Alcohol-based and other sanitizers may be used when dry sanitation is needed.

Sanitary Guidelines for Packinghouse Operations

Receiving incoming product: As much dirt from incoming onions and/or containers should be removed as is possible before entering the packinghouse. This reduces the spread of contamination from the field and speeds up sanitation activities since less dirt is present. Care should also be taken to avoid damaging onions during transport and loading onto the packing line.

Packinghouse equipment: Aside from sweeping up scales, onion culls, etc., off the floor, some packers do not clean the line equipment during the pack-out season. Remnants of product debris left on belts, roller conveyors, and sizing rings provide a rich source of materials for the growth of both storage and foodborne pathogens. When regular cleaning and sanitizing of the line equipment does not occur, packers are unable to establish what are called “clean breaks” (Krug et al., 2020). These clean breaks are critical to ensure that if a contamination problem is identified with a certain lot (or batch) of products, that contamination may be isolated to only that lot that was processed between sanitation events. Otherwise, if a problem resulting in a recall is found with a specific lot of onions, but the packer cannot demonstrate that the contamination was removed from the line by sanitation, it is possible that every onion processed on the line after the recalled lot must also be recalled. For packers that only clean and sanitize at the beginning of the pack-out season, this could result in the recall of an entire season's worth of onions.

Employee hygiene: Good worker hygiene is critical to reduce the spread of foodborne pathogens since these are frequently carried by humans. Employee training and monitoring of packinghouse sanitation practices (hand washing, personal hygiene) are important to reduce contamination of onions from workers. Sick workers should be excluded from work that involves contact with onions, food contact surfaces, or other workers if person-to-person transmission is likely.

Pest control: A pest control program should be in place to reduce the risk of contamination by rodents, birds, insects, or other pests. In an open or exposed packinghouse operation, the best control is regular monitoring and removal of discovered animals and their potential nesting locations. Product and/or product remnants will attract pests, so daily cleaning of the packinghouse to eliminate food sources is critical for an effective pest control program. Bait stations may be useful around the packinghouse exterior, while un-baited traps are recommended for interior locations so that pests are not baited into the packing area.

Facility sanitation: Packinghouse facilities have the potential for developing microbial growth on walls, tunnels, ceilings, floors, doors, and drains. Scheduled wash-down and sanitizing of the facility will reduce the potential for microbial growth. Regular maintenance and cleaning of the cooling system should be conducted, and condensation should be managed so it does not drip onto onions or food contact surfaces.

Production Costs of Onions

Enterprise budgets are used to estimate production costs and break-even analyses (Tables 13 and 14). The cost estimates included in the budgets should be for those inputs deemed necessary to achieve the specified yields over a period of years. Production practices, size of operation, yields, and prices can vary among farms. For these reasons, each grower should adapt budget estimates to reflect his or her situation. Table 13 shows the various break-even cost/price per 40-lb box of Vidalia onions. To be profitable, a grower needs a minimum yield of 306 (40 lb) boxes per acre and a minimum price of $12.83 per 40-lb box of Vidalia onions.

Type of Costs

Crop production costs include both variable (VC) and fixed costs (FC). The variable or operating costs vary with the amount of crop produced. Common variable costs include plants, fertilizer, chemicals, fuel, and labor. In this study, the preharvest (P-VC) was $3,001 per acre. The inputs that contributed heavily to the P-VC were plants, fungicides, transplanting, fertilizer, and irrigation. The cost of onion plants was $736, equivalent to 25% of total pre-variable costs. Fungicide applications contributed 13% while irrigation was 4.2% of the preharvest VC, respectively (Table 14). Total harvesting and marketing costs were $3,463, which comprised input costs such as burlap bags, hand harvesting costs, grading, labeled mesh bags, drying operation, boxes, general labor, and Vidalia Onion Committee Assessment fees, respectively. The biggest cost components were hand harvest labor ($898), grading ($901), boxes ($767), and general labor ($734). Adding the preharvest, harvesting, and marketing costs equals the total variable cost (TVC) of $6,464 (Table 14).

Fixed cost (FC) includes items such as equipment ownership (depreciation, interest, insurance, and taxes), management, and general overhead costs. Most of these FC are incurred even if little or no production takes place. This provides the grower an opportunity to analyze the costs at different stages of the production process. Land cost may be either a VC or an FC. Even if the land is owned, a cost is involved. Land cost was not included in this budget, but we acknowledge that it is a cost component. If land is double-cropped, charge each enterprise half the annual rate. Ownership costs for tractor and equipment (depreciation, interest, taxes, insurance, and shelter) are included as an FC per hr of use. The daily use of irrigation is considered a VC, while irrigation material and installation are classified as FC (Tables 13 and 14) expenses. Overhead and management costs were $450 and were calculated by taking 15% of all preharvest VC expenses. This figure compensates for management and farm costs that cannot be allocated to any one specific enterprise. Overhead items include utilities, pickup trucks, farm shop, equipment, and fees. Total budgeted cost per acre of producing onions is $7,695, which is the sum of total variable cost (TVC) plus total fixed cost (TFC), respectively. The preharvest VC and the FC decline rapidly with increases in yields.

Budget Uses

In addition to estimating the total costs (TC) and breakeven (BE) prices for producing onions, other uses can be made of the budgets. Estimates of the cash costs (out-of-pocket expenses) provide information on how much money needs to be borrowed. The cash cost estimates are most beneficial in preparing cash flow statements. In share leases, the landlord and tenant can use the cost estimates, by item, to more accurately determine an equitable share arrangement.

Risk-Rated Net Returns

Because yields and prices vary so much from year to year, an attempt has been made to estimate the "riskiness" of producing onions. Five different yields and prices are used in calculating risk. The "expected" values are those prices and yields a particular grower would anticipate exceeding half the time (half the time he would anticipate not to reach these values). Averages can be used for the expected values.

"Optimistic" values are those prices and yields a grower would expect to reach or exceed one year in six. The "pessimistic" values are poor prices and yields that would be expected one year in six. The "best" and "worst" values are those extreme levels that would occur once a lifetime (1 in 48). The risk-rated section (Table 15) shows a 99% chance of covering all costs. Half the time, the budgeted grower would expect a return of $5,505 or more for $22 and a yield of 600 boxes (40 lb). One year out of six, they would expect to make a maximum of $8,643 per acre and one year out of six to earn a minimum of $2,367 per acre.

Readers should recognize that the examples shown here are estimates. They should serve as guides for developing their own estimates. The budget tables presented in this document are available as spreadsheet files for "what if" analyses. Contact your county Extension office for a copy, or visit the budgets website maintained by UGA Ag Econ: https://agecon.uga.edu/extension/budgets.html.

Table 13. Breakeven Cost Analysis per 40-lb Box of Onions, 2024.

Breakeven (B/E) item	Cost
B/E per harvest variable cost per 40-lb box	$5.00
B/E harvest & marketing cost per 40-lb box	$5.77
B/E fixed cost per 40-lb box	$2.05
B/E total budgeted cost per 40-lb box	$12.83
B/E yield per acre (40-lb boxes)	$306.00

Table 14. Estimated Preharvest Cost of Producing Onions in Georgia, 2024.

Items	Unit	Quantity	Price	$/acre
Preharvest Variable Costs				
Plants and setting	thou	92.00	8.00	736.00
Set Plants	acre	1.00	500.00	500.00
Lime, applied	ton	0.33	47.20	15.58
Nitrogen	lb	120.00	0.90	108.00
Phosphorous	lb	120.00	0.65	78.00
Potassium	lb	120.00	0.50	60.00
Insecticide	acre	4.00	38.08	152.32
Fungicide	acre	10.00	41.87	418.70
Herbicide	acre	2.00	15.50	31.00
Machinery (fuel, lube, & maintenance)	acre	1.00	246.09	246.09
Land rent 1/-	acre	1.00	0.00	0.00
Crop Insurance	acre	1.00	400.00	400.00
Irrigation	appl	1.00	125.93	125.93
Interest on Oper. Cap.	$	2871.61	0.09	129.22
Total Preharvest Variable	acre	1.00		**3000.83**
Harvest and Marketing Variable Costs				
Hand harvest labor	boxes	570.00	1.58	898
General labor	hr	50.00	14.68	734
Grading	boxes	570.00	1.58	900.60
Labeled mesh bags	each	100.00	0.50	50.40
Cartons	each	570.00	1.31	746.70
Drying	boxes	570.00	0.11	59.85
Vidalia Onion Committee Assessment	bag	570.00	0.13	74.10
Total Harvest and Marketing	**$**			**3463.40**
Total Variable Costs	**$**			**6464.23**

Fixed Costs				
Machinery	acre	1.00	597.74	597.74
Irrigation	acre	1.00	183.01	183.01
Overhead and Management	$	3,000.83	0.15	450.13
Total Fixed Costs	**$**			**1,230.87**
Total Budgeted Cost Per Acre	**$**			**7,695.11**

Table 15. Risk-Rated Returns Over Total Costs of Producing Onions in Georgia, 2024.

	Best	Optimistic		Expected	Pessimistic		Worst
Net return levels ($)	8,643	7,597	6,551	5,505	4,459	3,413	2,367
Chances of obtaining this level or more	7%	16%	31%	50%			
Chances of obtaining this level or less				50%	31%	16%	7%
Chances for profit: 99% **Base Budgeted Net Revenue: $5,505**							

Production and Marketing of Onions

Import-Export Trend and Per Capita Consumption

Despite the quantity of onions produced in the United States (3.3 million tons in 2024), a significant quantity is still imported to supplement local supplies. The quantity of imported onions to the U.S. has been increasing steadily for the past decade. For instance, 1.2 million lb were imported in 2020, compared to 1.5 million lb in 2022 (Fig. 27). On the other hand, export growth has been decreasing from 0.7 million lb in 2020 to 0.6 million lb in 2022. Furthermore, the U.S. onion industry experienced a negative balance of trade of $518 million in 2022 with total export of $308 million to Canada ($223 million), Mexico ($51.2 million), Japan ($3.48 million), Bahamas ($3.32 million), and Chinese Taipei ($3.05 million), respectively, compared to a total import of $826 million imported from Mexico ($451 million), China ($95.9 million), Canada ($89 million, Peru ($74.2 million), and Spain ($73 million), respectively, in the same time period (Figure 32).

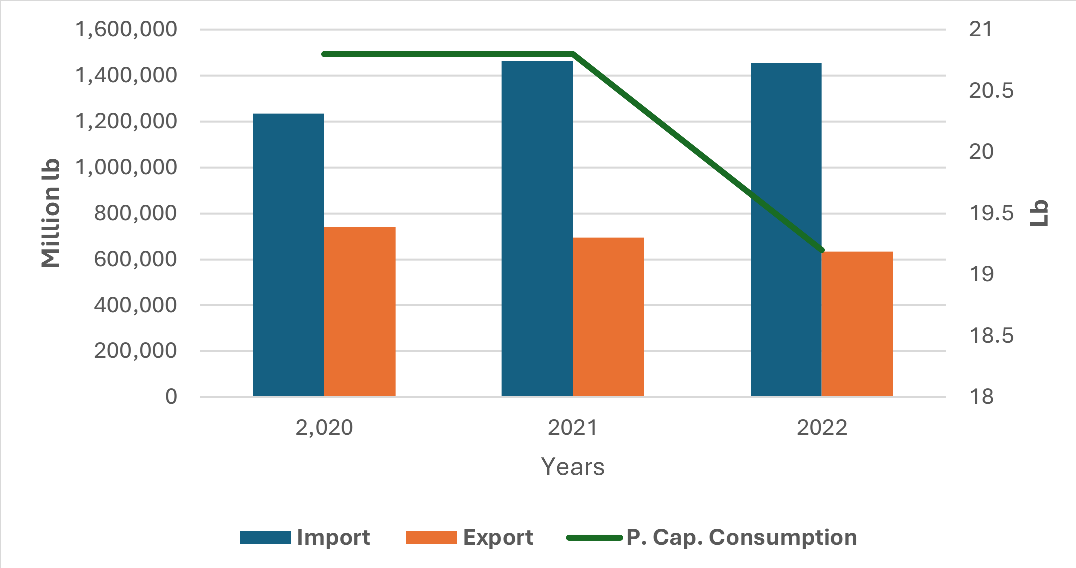

Figure 32. U.S. Fresh or Chilled Onion Import, Export, and Per Capita Consumption, 2020–2022. From "National potato and onion report," by the Agricultural Marketing Service, 2024, U.S. Department of Agriculture (https://www.ams.usda.gov/mnreports/fvdidnop.pdf).

It is interesting to note that for the past 2 years, the per capita consumption of onions has not changed, but there was a decline in 2022 (Figure 32). For instance, in 2021 and 2020, per capita onion consumption was the same at a record 20.8 lb compared to 19.21lb in 2019, 18.22lb in 2018, and 17.74 lb in 2017, respectively. This means that Americans are producing and eating more onions (Figure 32). The highest per capita consumption was in 2007 when 21.6 lb were reported. About 1/3 of this is due to sweet onion consumption, with the Vidalia onion being a significant, successful part.

Prices for onions have remained strong in Georgia compared to other states. For instance, from July 19, 2024, the Wholesale Terminal Market prices for Georgia yellow onion were $30 for 40 lb sack compared to $18 for a 50 lb sack from North Carolina in the Boston, Massachusetts Terminal Market. Similarly, in the New York Terminal Market, Georgia obtained an average of $31 for a 40 lb box compared to $20 for 50 lb sacks of yellow, extra jumbo onions from Idaho (Agricultural Marketing Service, 2024).

Georgia experienced the peak onion planted area of 12,686 acres in 2018. Thereafter, acreages started to decline to the lowest of 9,950 acres in 2020. However, acreages increased to 11,285 in 2021 and slightly decreased to 11,034 in 2022 (Center for Agribusiness and Economic Development, 2024). On the other hand, the farm gate value was $150 million in 2018, with a huge decrease to $133 million and $134 million in 2019 and 2020, respectively, before making a comeback of $168 million in 2021 and a peak of $174 million in 2022 (Figure 33).

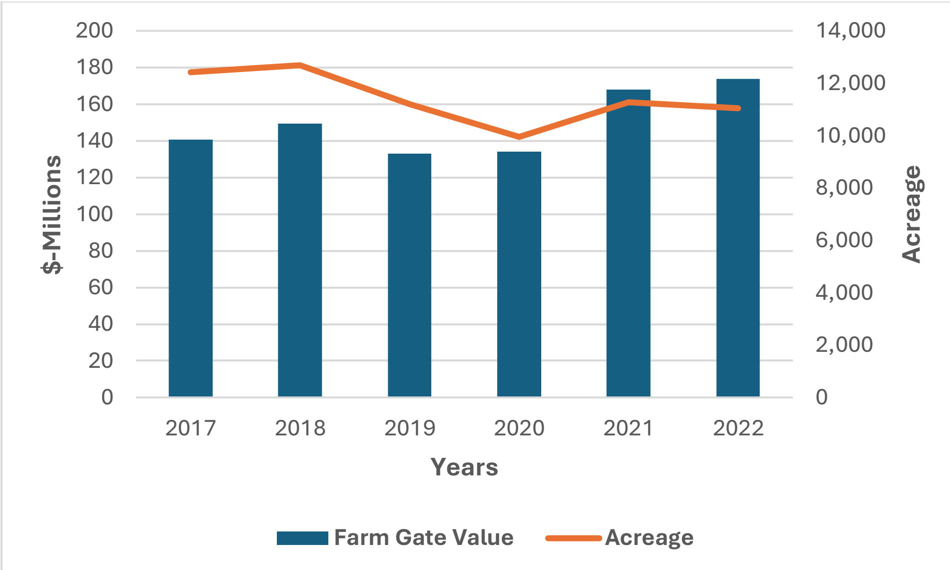

Figure 33. Georgia Onion Acreages and Farm Gate Value, 2017–2022. From Georgia Farm Gate Value reports (2017–2024; https://caed.uga.edu/publications/farm-gate-value.html).

Onions, along with other alliums, have been touted in recent years for several health benefits, which have also contributed to increased consumption. China is the leading producer of onions in the world, followed by India, and the United States is ranked third (Table 16). Other important producing countries are Pakistan, Turkey, Iran, Egypt, Russia, Brazil, and Mexico. In 2023, China produced 20.5 million tons, while India produced 13.4 million tons and the United States produced 3.3 million tons (Nag, 2017).

Table 16. Top 10 Onion-Producing Countries, 2024.

Rank	Country Name	Tons Production
1	China	20,507.759
2	India	13,372,100
3	United States of America	3,320,870
4	Egypt	2,208,080
5	Iran	1,922,970
6	Turkey	1,900,000
7	Pakistan	1,701,100
8	Brazil	1,556,000
9	Russia	1,536,300

10	Republic of Korea	1,411,650

From "The top onion producing countries in the world," by O. S. Nag, 2017, World Atlas (https://www.worldatlas.com/articles/the-top-onion-producing-countries-in-the-world.html).

Onions are ranked second among the top 10 vegetables produced in the state of Georgia in 2022. Georgia produces primarily short-day sweet Vidalia onions. In 2022, onions ranked second in terms of farm gate value, generating $174 million, equivalent to 13.3% of the total vegetable farm gate value of $1.31 billion (Table 17).

Table 17. Top 10 Vegetables in Georgia (2022).

Ranking	Commodity	Value	Percentage
1	Sweet corn	$187,848,254	14.39
2	Onion	$173,945,307	13.32
3	Bell Peppers	$152,758,734	11.70
4	Watermelon	$142,671,769	10.93
5	Tomato	$83,518,714	6.39
6	Cucumbers	$82,419,256	6.31
7	Yellow squash	$50,484,377	3.86
8	Zucchini	$42,068,361	3.22
9	Carrots	$41,946,088	3.21
10	Cabbage	$36,496,044	2.79

From the 2022 Georgia Farm Gate Value report (https://caed.uga.edu/publications/farm-gate-value.html).

Although vegetable production is predominantly in South Georgia, some counties do better than others. Table 18 shows the top 10 counties responsible for most of the onion production in the state. In 2022, Tattnall County was ranked first, generating $66 million in farm gate value, while Union County ranked 10th with $48,600.

Table 18. Top 10 Onion-Producing Georgia Counties by Value (2022)

Ranking	County	Acres	Farm Gate Value
1	Tattnall	4,090	$66,257,514
2	Toombs	3,840	$55,296,000
3	Evans	1,070	$21,186,000
4	Candler	448	$8,870,400
5	Bulloch	523	$8,472,600
6	Wayne	588	$6,585,600
7	Montgomery	273	$4,040,400
8	Emanuel	180	$2,916,000
9	Telfair	14	$189,000
10	Union	3	$48,600

From the 2022 Georgia Farm Gate Value report (https://caed.uga.edu/publications/farm-gate-value.html).

At the state level, Georgia's onion farm gate value decreased in 2019 and 2020, then grew steadily from 2021 and peaked in 2022. For instance, onions generated $141 million in 2017 and a record $150 million in 2018. The value decreased to $133 million in 2019 and increased to $174 million in 2022 (Figure 34).

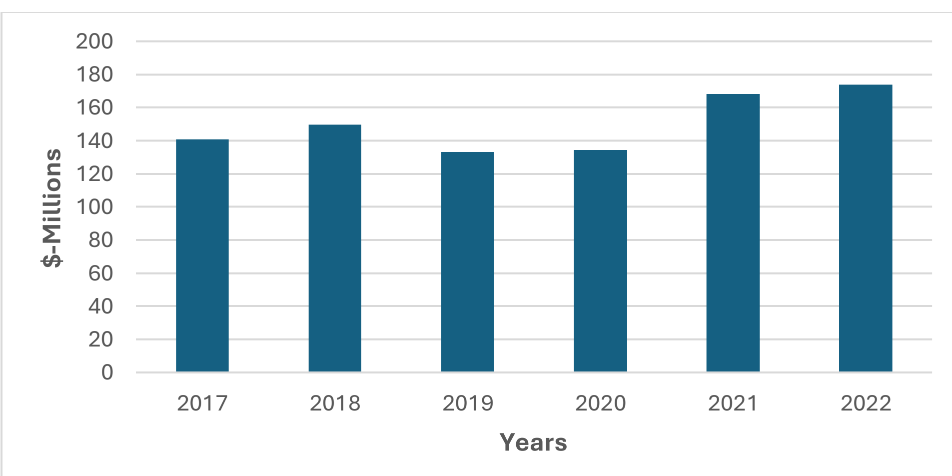

Figure 34. Georgia Farm Gate Value for Onion, 2017–2022. From Georgia Farm Gate Value reports (multiple years; https://caed.uga.edu/publications/farm-gate-value.html).

Conclusion

Onions are an important commercial vegetable in the state of Georgia in terms of production acreages, yield and farm gate value respectively. If the growers continue to adhere to the recommendations from Extension Specialists and Researchers, this crop will continue to rank high in the top 10 vegetables produced in the state. Although the United States is ranked third in the world for onion production, a significant quantity of onions is still imported to complement domestic consumption. The U.S. imports more onions than it exports.

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