UGA extension

# Onion Production Guide

# Sections and Authors

*Editor – George E. Boyhan and W. Terry Kelley*



# Forward

This Extension bulletin is the result of collaborative work across several departments including Horticulture, Plant Pathology, Crop & Soil Science, Entomology, Biological & Agricultural Engineering, Food Science & Technology and Agricultural Economics.

This publication represents the latest information available on the production of short-day onions in South Georgia. The authors would like to extend their thanks to the many people involved in editing, proofing, and putting this document into its final form.

# Introduction

*George E. Boyhan – Extension Horticulturist*

Onions are one of the oldest vegetables in continuous cultivation dating back to at least 4,000 BC. The ancient Egyptians are known to have cultivated this crop along the Nile River. There are no known wild ancestors but, the center of origin is believed to be Afghanistan and the surrounding region. Onions are among the most widely adapted vegetable crops. They can be grown from the tropics to subarctic regions. This adaptation is primarily due to differing response to day length. Unlike most other species, day length influences bulbing in onions as opposed to flowering. Onion bulbs are placed into three groups based on their response to hours of day length. The short-day bulb varieties with day lengths of 11-12 hours while intermediate bulb varieties with day lengths of 13-14 hours and are found in the mid-temperate regions of this country; finally, the long-day varieties are adapted to the most northern climes of the United States as well as Canada and bulb with day lengths of 16 hours or greater.

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 southeast 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, YB986, was selected from Excel, which in turn was derived from White Bermuda.

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, Georgia. These mild onions were immediately popular with customers. At the beginning of the depression, these onions sold for $3.50 a 50-pound 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, Georgia. They would buy the onions and distribute them through their stores. Slowly the industry began to gain a national reputation.

In order to help promote the onions further, onion festivals were started in both Vidalia and Glennville in the mid 1970s. Approximately 600 acres of onions were produced at the time. Growth continued during the next decade. In 1986, 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. State recognition, however, did not give the industry the national protection it needed. The industry obtained Federal Market Order 955 giving the industry national protection in 1989. The Vidalia Onion Committee was formed to oversee the federal market order. Growers are required to register and pay funds based on their production to support the industry. The collected money is used for national and international promotional campaigns and for onion research.

In 1989, the industry began to adopt controlled atmosphere (CA) storage. CA uses a low-oxygen, high carbon dioxide refrigerated environment to store onions. This allows the industry to expand their marketing opportunities well into the fall and winter months. The adoption of the federal market order and CA storage has allowed this industry to grow to its current level of approximately 14,000 acres.

# Transplant Production

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Short-day onions can be grown from both seed and transplants, but the majority are grown from transplants.

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. Avoid sites with a history of onion diseases and severe weed problems.

Once a site is selected, take a soil test to determine the optimum level of fertility and soil pH. Recent additions to the soil test recommendations give specific recommendations for plantbed onions. When submitting a soil sample to the University of Georgia's Soil, Plant & Water Analysis Lab, indicate that they are for transplants or plantbed onion production. The site should be deep turned to bury any residue from the previous crop. Several different seeders are available for transplanting. Set these to sow 60-70 seed per linear foot. Using a Plant-It Jr. four-hopper transplanter, set the plates to No. 24. This should give the needed seeding rate for plantbeds. 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 as long as they are capable of sowing 60-70 seed per linear foot and can consistently plant the seed at the proper depth (1/4-1/2 inch).

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

Nitrogen recommendations on Coastal Plain soils range from 100-130 pounds of nitrogen per acre. On Piedmont, Mountain and Limestone Valley soils, apply 90-120 pounds per acre. Table 1 (page 5) indicates the phosphorus and potassium recommendations based on soil residual phosphorus and potassium levels.

In addition, apply boron at 1 pound per acre. If zinc results are low, apply 5 pounds of zinc per acre. Sulfur is critical for proper onion production. This is particularly true on the Coastal Plain soils of south Georgia that are very low in sulfur. Sulfur, at a rate of 20-40 pounds per acre, will be required to produce quality onion transplants on these sandy loam soils.

A typical fertility program consists of 300-400 pounds per acre of 10-10-10 with 12 percent sulfur applied preplant. This supplies 30-40 pounds of N-P-K along with 36-48 pounds of S. Follow this with additional applications of P and K according to soil test recommendations. Generally, additional P is not needed, while additional K can be supplied as potassium nitrate (13-0-44). Supply additional N in one to two applications of calcium nitrate (15.5-0-0) applied at 4 and 6 weeks post seeding. Note that any fertilizer that supplies the required nutrients as required by the soil test can be used to produce plantbed onions. More recent work indicates that high P applications at plantbed seeding have no effect. Phosphorus can have limited availability during periods of cool soil temperature. Seeding plantbeds in September, soil temperatures are sufficiently high to avoid P deficiency. However, plantbeds that have not been fertilized properly at seeding may require "pop-up" (high P) fertilizer to over-come deficiencies during the cooler months of November and December.

It is critically important that seedbeds be irrigated regularly to develop a good plant stand. Applying 1/10 inch of water several times a day may ensure consistent soil moisture. See section on irrigation.

Plants are ready for harvest in about 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. Approximately half of the tops are cut from the transplants, usually with a machete. 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. Take care 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. Avoid overnight storage in these bags whenever possible but, if necessary, remove them from the field to a cool dry location.

**Table 1. Recommendations for phosphorus and potassium based on soil test analysis for plant bed onion production.**

| | N (lb./acre) | | | | |
|---|---|---|---|---|---|
| pH | Coastal Plain | Piedmont | Soil Test P & K | P (lb./acre) | K (lb./acre) |
| 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

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As mentioned earlier, the type of onion grown in south Georgia is a short-day onion that bulbs during the short days of winter (11-12 hours day length). Although no research has been done in this area, it may be possible to grow intermediate day onions in north Georgia. They would not, however, be as mild as the south Georgia Vidalia onions.

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 type 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). Recently, additional 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. The Georgia Department of Agriculture has already excluded five varieties, 'Sugar Queen,' 'Spring Express,' 'Sweet Dixie,' WI-3115, and WI-609. Varieties the Georgia Department of Agriculture recommends growing as Vidalia onions are listed in Table 2 (page 7).

Onion varieties grown in southeast Georgia fall into three broad maturity classes: early, mid-season, or late. There can be considerable overlap in these categories and not all varieties will perform the same as to their maturity from one year to the next. Along with maturity, varieties perform differently on a wide range of quality attributes as well as yield. Varieties can differ for pungency, sugar content, disease resistance, seed stem formation, double centers, bulb shape, and bulb size. Consider all of these characteristics when making decisions on variety selection. Growers wishing to try new varieties should consult University of Georgia 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 planting new varieties should grow them on limited acreage. The grower can get a feel for their new varieties' performance potential under their growing conditions. In addition, growers wishing to grow Vidalia onions should check with the Georgia Department of Agriculture for the current allowed varieties.

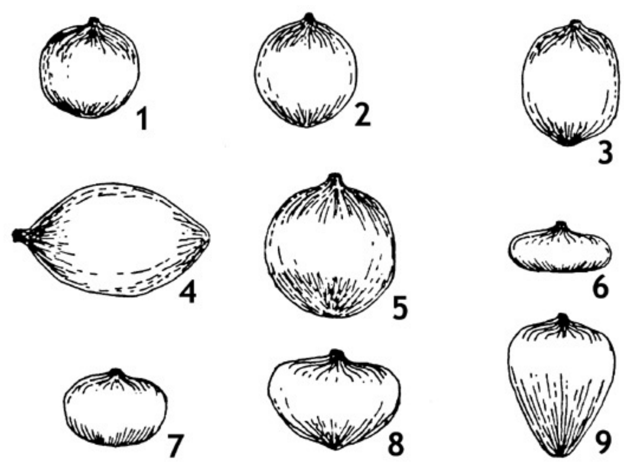


**Figure 1**. Bulb Shapes: 1 - flattened globe; 2 - globe; 3 - high globe; 4 - spindle; 5 - Spanish; 6 - flat; 7 - thick flat; 8 - Granex; 9 - top *(Courtesy of Texas A&M University)*

**Table 2. List of current legal Vidalia onion varieties.**

| Variety | Source | Season |
|---|---|---|
| Georgia Boy | D. Palmer Seed | Mid- |
| Mr. Buck | D. Palmer Seed | Mid- |
| Ohoopee Sweet | D. Palmer Seed | Mid- |
| Sapelo Sweet | D. Palmer Seed | Mid- |
| Miss Megan | D. Palmer Seed | Mid- |
| YG 15082 | Dessert Seed | Mid- |
| HSX-61304 | Hortag Seed | Late |
| Caramelo | Nunhems USA Inc. | Mid- |
| Nirvana | Nunhems USA Inc. | Mid- |
| Sweet Caroline | Nunhems USA Inc. | Mid- |
| Sweet Melody | Nunhems USA Inc. | Mid- |
| Sweet Vidalia | Nunhems USA Inc. | Mid- |
| Sweet Jasper | Sakata Seed | Mid- |
| Sweet Harvest | Sakata Seed | Mid- |
| XON-403Y | Sakata Seed | Mid- |
| Century | Seminis Seed | Mid- |
| EX 19013 | Seminis Seed | Mid- |
| Granex 33 | Seminis Seed | Mid- |
| Granex Yellow, PRR | Seminis Seed | Mid- |
| Savannah Sweet | Seminis Seed | Mid- |
| Golden Eye | Seminis Seed | Mid- |
| Honeycomb | Shamrock Seed | Early |
| Sugar Belle F1 | Shamrock Seed | Early |
| Honeybee | Shamrock Seed | Early |
| Candy Ann (SS 2005) | Solar Seed | Early |
| WI-129 | Wannamaker Seed | Early |

# Soils and Fertilizer Management

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Onions grow best on fertile, well-drained soils. Tifton series 1 and 2 soils are found in the Vidalia onion area and are well suited for onion production. Most sandy loam, loamy sand or sandy soils are also advantageous to sweet onion production. These soils 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 that can lead to pungent onions. Sandy soils are difficult to manage because they require more fertilizer and water.

Always base fertilizer and lime requirements on a recent, properly obtained soil sample. Check with your local county Extension office or crop consultant regarding proper procedures for soil sampling and interpretation of results. Take the soil test a few months prior to crop establishment in order 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 2-3 months before land preparation to bring the pH to the optimum range of 6.2-6.5. 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. Also, high rates of fertilizer used in producing onions cause the pH to drop 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 yields. Calcium and phosphorous deficiencies can often be linked to low pH, even though soil tests indicate adequate levels. Foliar applications of calcium may help overcome calcium deficiencies. But phosphorus deficiencies due to low pH can be difficult to correct during the growing season.

Onions require more fertilizer than most vegetable crops because fertilization of both plant beds and dry bulb onions must be considered. They respond well to additional fertilizer applied 40-60 days after seeding or transplanting. The method of fertilizer application is very important in obtaining maximum yield, with multiple applications ensuring good yields. This increases the amount of fertilizer used by the plant and lessens the amount lost from leaching. More recent research indicates that good results can be obtained with as few as three fertilizer applications. Preplant fertilizer will vary with the natural fertility and cropping history. Proper application methods and function of various nutrients are outlined below. Table 3 (page 10) 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 and disease, and to production of flower stalks. Onions, heavily fertilized with nitrogen, are believed to not store well. Finally, excess nitrogen late in the growing season is believed to delay maturity and causes double centers. Make the final nitrogen application at least 4 weeks prior to harvest. Rates of nitrogen vary depending on soil type, rainfall, irrigation, plant populations, and method and timing of applications. Dry bulb production, from transplanting, requires between 125-150 pounds per acre nitrogen. It is usually best to incorporate 25-30 percent of the recommended nitrogen prior to planting; apply the remainder in two to three split applications.

**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, under most conditions, apply all of the P preplant and incorporated before transplanting. Count this amount as part of the total seasonal fertilizer application. Table 4 (page 10) shows the recommended phosphorous 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 subject to leaching from heavy rainfall or irrigation. Therefore, it is best to split K applications by incorporating 30-50 percent of the recommended K before planting and splitting the remainder in 1-2 side dress applications. A low K level makes plants more susceptible to cold injury. Table 4 (page 11) lists recommended K applications based on soil test results.

**Sulfur (S)** is an essential element for plant growth. Early applications of sulfur are advisable in direct-seeded and transplanted onions. To minimize pungency, apply fertilizers containing S before the end of January. Research conducted in Georgia on S and onion pungency shows that pungency (pyruvate analysis) of mature onions increases with high rates of S or whenever S applications are made after late January. Therefore, do not apply S to onions after late January unless the onions exhibit S deficiency. Do not completely eliminate S from the fertility program. Apply 40-60 pounds of elemental S with half incorporated at transplanting or seeding and half applied at the first side dress application. Do not apply S in rates higher than 40-60 pounds per acre.

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

**Zinc (Zn)** levels determined to be low by soil testing can be corrected by applying 5 pounds of Zn per acre. Excessive amounts of Zn can be toxic, so apply only if 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 Mg. However, if soil pH is adequate and the soil-test Mg level is low, apply 25 pounds of Mg per acre in the preplant fertilizer.

Recently several slow release fertilizers have been introduced to the Vidalia growing region. These fertilizers have performed well and can be considered in a fertility program. These fertilizers, however, have not proven satisfactory for single fertilizer application.

A complete fertilizer with minor elements will provide most of the other required nutrients. Micronutrients can become toxic if excessively applied. Apply them only when needed and in precise amounts. Routine visual inspection of onion fields to watch for nutrient deficiencies is always important. However, during periods of high rainfall or frequent irrigation, be particularly aware of the potential for nutrient deficiencies to occur.

Deficiencies of major nutrients cannot be feasibly corrected through foliar nutrient applications. 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. Thus, it is always best to supply adequate amounts of these nutrients through your basic soil fertility program. Plants use nutrients more efficiently when the nutrients are taken up from the soil. By the time you visually see deficiency symptoms, you have probably already lost some potential yield.

## Plant Tissue Analysis

Plant tissue analysis is an excellent tool to evaluate crop nutrient status. Use periodic tissue analysis 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. Take a sample of 20-30 leaves from the field area(s) in question. Check with your local county Extension office or crop consultant on proper tissue analysis techniques. The University of Georgia, through its Soil, Plant & Water Analysis Lab can analyze your samples. Table 5 (page 10) shows critical ranges for nutrient concentrations in onion tissue for the crop stage just prior to bulb initiation.

**Table 3. Sample fertilizer recommendations for transplanted onions with a plant population of 60,000 to 80,000 plants per acre. Make adjustments for soil test levels other than medium P and medium K.**

| Timing | Amount (lb./acre) | Type | Method | N | $P_2O_5$ | $K_2O$ | S |
|---|---|---|---|---|---|---|---|
| Pre-plant | 400 | 10-10-10 with 12% S | Broadcast & incorporate | 40 | 40 | 40 | 48 |
| January | 85 | 0-0-60 | Broadcast | 0 | 0 | 50 | |
| | 250 | 0-20-0 | | 0 | 50 | 0 | |
| | 200 | 15.5-0-0 | | 31 | 0 | 0 | |
| February | 520 | 15.5-0-0 | Broadcast | 81 | 0 | 0 | |
| **Total** | | | | **152** | **90** | **90** | **48** |

With heavy rains, additional nitrogen and sulfur may be warranted. Other fertilizer formulations and application methods may be used as long as the soil test recommendations are met.

**Table 4. Recommended potassium and phosphorous applications based on soil test ratings of each nutrient.***

| | Potassium | | | | |
|---|---|---|---|---|---|
| **Phosphorous Rating** | **Low** | **Medium** | **High** | **Very High** | **Overload** |
| | **(Pounds 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: 130-150 lb./acre N. Piedmont, Mountain and Limestone Valley Soils: 110-130 lb./acre N.

**Table 5. Plant tissue analysis critical values for dry bulb onions.**

| **Nutrient** | **N** | **P** | **K** | **Ca** | **Mg** | **S** | **Fe** | **Mn** | **Zn** | **B** | **Cu** | **Mo** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Units** | **Percent** | | | | | | **Parts per million** | | | | | |
| **Status** | | | | | | | | | | | | |
| Deficient | <2.0 | 0.20 | 1.5 | 0.6 | 0.15 | 0.2 | 50 | 10 | 15 | 10 | 5 | – |
| Adequate | 2.0-3.0 | 0.20-0.50 | 1.5-3.0 | 0.6-0.8 | 0.15-0.30 | 0.2-0.6 | 50-100 | 10-20 | 15-20 | 10-25 | 5-10 | – |
| High | >3.0 | 0.50 | 3.0 | 0.8 | 0.30 | 0.6 | 100 | 20 | 20 | 25 | 10 | – |
| Toxic | – | – | – | – | – | – | – | – | – | – | 100 | – |

Adapted from Vegetable Production Guide for Florida. Pub. No. SP 170. Univ. of Florida Cooperative Extension Service. 1999.

# Cultural Practices

*George Boyhan and W. Terry Kelley – Extension Horticulturists*

Transplants (see Transplant Production) 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. Consequently, they will have a smaller percent of jumbos. Plant early varieties prior to the end of December. If planted late, they will have lower yields and smaller bulbs because they are strongly day length sensitive and will "go down" (tops fall over at the neck) or reach maturity earlier than other varieties.

**Figure 3.** Pegger

Transplants are field set on slightly raised beds approximately 4 feet wide. Beds are 6 feet center to center. These beds or panels, as they are sometimes called, will have four rows of onions spaced 12-14 inches apart and a spacing of 4.5- 6 inches within the row (Figure 2). The spacing is determined by peg spacing on a pegger used to place holes in the bed surface 1- 2 inches deep (Figure 3). Transplants are hand set in each hole.

**Figure 2.** Typical onion field.

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.

Harvest maturity is reached when 20-50 percent of the onion tops are down. In most seasons, onion neck tissue breaks down when the plant is mature. Although this is a good rule-of-thumb for determining when onions mature, the tops may not go down as readily in some years or for some varieties. In addition, early varieties are very day length sensitive and usually go down early and uniformly. Harvest these early varieties when 100 percent of the tops go down. They can be allowed to stay in the field for a week after tops go down and will continue to enlarge. This will increase the yield as the bulbs continue to increase in size. Knowing the variety and carefully inspecting the crop is the best method to determine maturity. Whether the tops go down or not, the neck tissue will become soft, pliable, and weak at maturity. Onions harvested too early may be soft and not dry down sufficiently during curing. In addition, they may begin to grow because they are not completely dormant. If the onions are harvested too late, there may be an increase in post-harvest diseases and sun-scald on the shoulder of the bulb. Although $F_1$ hybrids will have a narrow window of maturity, they will not all mature at once. Generally, a field of onions will be harvested before all the bulbs have their tops down.

Onions are prone to physiological disorders that growers should try to minimize. One such disorder is 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 degrees F) are all believed to influence double formation. Some varieties are more prone to production of doubles than others. Varieties prone to doubling should be seeded a week or so later on the plant beds as well as transplanted a bit later to minimize this disorder.

Onions are biennials, forming bulbs the first year. These 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 are 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.

Generally, onions can withstand light to heavy frosts, but hard freezes can result in onion damage. Freeze injury may be readily detectable as translucent or water soaked outer scales of the bulbs. One or two days 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. Apparently the growing point is damaged to the extent that two growing points develop. Under severe freeze conditions the plant may be killed. Control of freeze and frost injury is usually done by cultivating the fields, if such an event is anticipated. Cultivating fields results in a layer of moist soil at the surface that acts as insulation. This holds the day's heat in the soil around the bulb and root. The downside to cultivating is the possible increase of disease caused by throwing up contaminated soil on tender onion tissue.

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

Sun-scald will occur at the shoulder of all onions that are exposed to sunlight for an extended period of time. 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. Under severe conditions, the internal tissue may actually cook or become soft and translucent.

Translucent scale is a physiological disorder similar in appearance to freeze injury. The big difference is 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 post-harvest phenomenon caused by high $CO_2$ in storage facilities. This is most likely to occur in refrigerated storage without adequate ventilation. $CO_2$ levels above 8 percent will increase the chance of translucent scale. Growers and packers should carefully monitor storage facilities to prevent this.

Physical damage of onions may 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 (0.125-0.25 inch in diameter) white or yellow lesions on the leaves. The shoulders of the exposed bulbs will often have a dimpled feel. In severe cases, the crop can be defoliated and destroyed.

Occasionally plants may exhibit a striped appearance. If this is widespread in a field, S 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

*Kerry Harrison – Extension Engineer*

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 25-50 percent more than dry land onions. Irrigated fields typically yield a higher percentage of large and 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 commonly used systems are center pivots and traveling guns.

Center pivot systems are generally one of the lowest cost systems per acre to install and require very little labor to operate. If properly maintained, they apply water uniformly, and because of the low pressure required to operate them, they are generally energy efficient. They are not well adapted to small, irregular shaped fields. Unless the system is towable, it is restricted to use in only one field. If a farmer has a limited amount of irrigated land, this characteristic can be detrimental to desirable crop rotations.

Traveling guns are mobile systems that can be moved from field to field or farm to farm. They can be used on almost any shaped field. They do require high water pressure to operate and consequently require more fuel per acre-inch of water than the center pivot. Traveling guns require a considerable amount of labor to operate. These systems tend to increase soil compaction and are harsh on young plants.

There has been interest in installing drip irrigation systems similar to those used in other vegetable production (bell pepper, tomato, etc.). The drip irrigation tubes are commonly referred to as "tape." These systems have very little history in Georgia (as related to onion production) and should be used with caution. Tape systems work well when properly managed. If you are familiar with managing this type of drip irrigation, you are well on the way to a better understanding of the situation. If you have never used drip irrigation, carefully consider what changes of your irrigation management may be necessary to make this type irrigation successful.

## Irrigation Scheduling

Water use of onions varies considerably throughout the growing period and varies with weather conditions. The peak water demand for onions can be as high as 1.5- 2 inches per week. Peak use generally occurs during the latter stages of bulb enlargement especially during periods of warm weather. However, there are other stages when supplemental water may be needed.

Water transplanted onions very soon after setting. About 1/2-inch applied at this time will help establish good contact between the soil and roots, and assure a good stand.

During the next 2-3 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, irrigate whenever the soil becomes dry in the top 6 inches. Irrigation amounts should be limited to about 1/2-inch 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 inches or less. Because of the shallow rooting depth, irrigation applications should not exceed 1 inch. Typical applications should range between 0.6-1 inch for loamy soils and for sandy soils, respectively. During dry weather, irrigate two to 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 tensiometers or electric resistance blocks or any other moisture sensor (e.g., TDR) 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 4-6 inches and one at 10-12 inches. The ideal range for soil moisture is between (soil tension) 5-20 centibars for most Coastal Plain soils. Readings of less than 5 indicates saturated conditions and above 20 indicate the soil is becoming dry. If you use a center pivot or traveling gun, start early enough so the last part of the field to get watered does not get too dry before the system gets there.

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

*Paul E. Sumner – Extension Engineer*

Two types of sprayers, boom and air-assisted, are used for applying insecticides, fungicides, herbicides, and foliar fertilizers. Air-assisted sprayers (Figure 4) use 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 5-7 gallons per minute (gpm) per 100-gallon tank capacity. Boom output will vary depending upon the number and size of nozzles. Allow 20-30 percent for pump wear when determining pump capacity. Pump capacities are given in gallons per minute. The pump must produce the desired operating pressure for the spraying job to be done. Pressures are indicated as pounds per square inch (psi). The pump must be able to withstand the chemical spray materials without excessive corrosion or wear. Use care in selecting a pump if wettable powders are to be used as these materials will increase pump wear.

Before selecting a pump, consider factors such as cost, service, operating speeds, flow rate, pressure and durability. For spraying vegetable crops, a diaphragm pump is preferred because of serviceability and pressures required.

## Nozzles

Nozzle selection is one of the most important decisions made related to pesticide applications. The type of nozzle not only determines 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 commonly used for ground application of agricultural chemicals for onions are the 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 20-30 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. Operate drift reduction and turbo drop nozzles at 40 psi. Flooding fan and wide angle cone nozzles should be operated at 15-18 psi. These nozzles will achieve uniform application of the chemical if they are uniformly spaced along the boom. Flat fan nozzles should overlap 50-60 percent.

### 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 60-200 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 insecticide 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 consider other types 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 10-12 inch 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 ounces 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 time period. Each nozzle should be within 10 percent of the average output. If necessary, replace with new nozzles. 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 an active ingredient is involved.

1. From Table 6 (page 17), determine the distance to drive in the field (two or more runs are suggested). 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.
3. With sprayer sitting still and operating at same throttle setting or **engine RPM** as used in Step 2, adjust pressure to the desired setting. **Machine must be operated at 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 ounces, the sprayer will apply 18 gallons per acre. Adjust applicator speed, pressure, nozzle size, etc., to obtain recommended rates. If speed is adjusted, start at Step 2 and recalibrate. If pressure or nozzles are changed, start at Step 3 and recalibrate.

**Table 6. Distance to measure to spray 1/128 acre. One ounce discharged equals one gallon per acre.**

| Nozzle Spacing (inches) | Distance (feet) | Nozzle Spacing (inches) | Distance (feet) |
|---|---|---|---|
| 6 | 681 | 20 | 204 |
| 8 | 510 | 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 the spacing expressed in feet into 340. Example: Calibration distance for a 13" band = 340 ÷ 13/12 = 313 feet.

# Diseases of Vidalia Onions

*David B. Langston, Jr. – Extension Plant Pathologist*

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

## 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, so 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 not produce useable bulbs. Plants infected later are stunted and produce small, unmarketable bulbs.

**Management Options**: Using a long rotation to non-related crops (3-7 years) is the key management strategy for reducing losses to pink root. 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 degrees F, so delaying planting until soil temperatures average 75 degrees F or below will allow onions infected with pink root to grow and develop prior to temperatures that enhance infection. Harvesting onions prior to soil temperatures reaching 79 degrees F allows onions to escape further pink root infection. Fumigation with metam sodium, chloropicrin and 1,3-D dichloropropene (Telone) is shown to increase yields when onions have been planted to fields heavily infested with pink root. Consider onion varieties resistant to pink root and have horticulturally acceptable qualities. Research is continuing to evaluate fumigants on onion performance.

**Figure 6**. Pink colored roots of onions 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 that later become necrotic. This yellowing and/or necrosis may progress towards the base of infected plants. Sometimes leaves of infected plants exhibit curling or curving. Infected bulbs, when cut vertically, will show a brown discoloration in the basal plate (Figure 7). This discoloration moves 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.

**Figure 7.** Onion basal plate infected with Fusarium basal rot

**Management Options**: Like pink root, using a long rotation (4 or more years) to non-related crops is the 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 degrees F will help minimize losses. Resistance to Fusarium basal rot has been identified in some commercial onion cultivars (check on current varieties).

## Fungal Diseases Affecting Above Ground Plant Parts

### Botrytis Neck Rot

Botrytis neck rot is the most damaging fungal disease affecting 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 discernable 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.

**Figure 8.** Gray sporulation of Botrytis

**Figure 9.** Reddish brown discoloration of neck rot onion scales caused by Botrytis neck rot

**Management Options**: Harvesting healthy mature onions with a well-dried neck 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 degrees F will cause the outer scales to dry down and become barriers to Botrytis infection. Storing onions near 34 degrees F at approximately 70 percent relative humidity reduces 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 boscolid and pyraclostrobin, as well as these products individually, have 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 direction for use. For questions on a specific program of disease control, contact your local county Extension agent.

## Botrytis Leaf Blight

Botrytis leaf blight caused by *Botrytis squamosa* is another Botrytis disease. 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 degrees F.

**Symptoms**: Initial symptoms of Botrytis leaf blight are small (less than .25" 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.

**Figure 10**. Pale lesions caused by Botrytis leaf blight

**Management Options**: Preventive spray schedules containing the fungicides maneb, mancozeb, and chlorothalonil are the primary means used to suppress development of Botrytis leaf blight. In addition, iprodione, cyprodinil and fludioxonil, boscolid, and pyraclostrobin represent newer materials that are effective against this pathogen that growers may wish to integrate into their disease management program. Destruction of cull piles, deep soil turning, and long rotations are also recommended to reduce losses to this disease.

## 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 percent or higher for 12 or more hours), inoculum becomes wind-borne and spreads to new foliage. Infection is highest at 77 degrees F. Older plant tissue is more susceptible to infection by purple blotch. Thrips feeding is thought to increase 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.

**Figure 11**. Elliptical lesion characteristic of purple blotch

**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. Spray schedules including mancozeb, chlorothalonil, and iprodione will suppress purple blotch. In addition, boscolid and pyraclostrobin are effective against this disease. Intensify these schedules later in the season during periods of prolonged leaf wetness and high relative humidity.

## 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.

**Figure 12**. Dark sporulation indicative of Stemphylium leaf blight

**Management Options**: Practices used to suppress purple blotch will generally reduce losses to Stemphylium leaf blight. However, unlike purple blotch, the fungicides iprodione, boscolid, and pyraclostrobin are the only fungicides thought to be effective against Stemphylium leaf blight.

## Downy Mildew

Onion downy mildew, caused by the fungus *Peronospora destructor,* is very common throughout most areas of the world, but 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 50-55 degrees F, long periods of leaf wetness and/or high relative humidity (95 percent) 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.

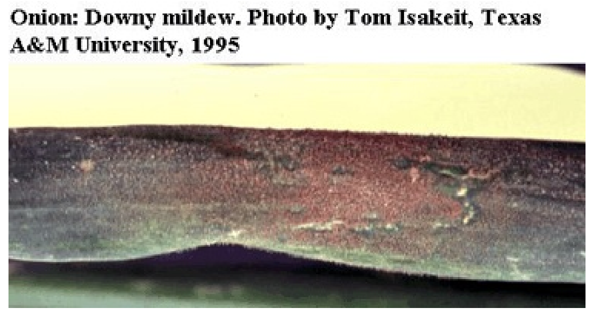


**Figure 13**. Velvety sporulation of the downy mildew fungus

**Management Options**: Management practices that ensure good air-flow 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. Fungicides such as mefenoxam, fosetyl-Al, chlorothalonil and mancozeb should be used at the first report of disease in the growing area.

# Bacterial Diseases

## Bacterial Streak and Bulb Rot

This bacterial disease of onion, caused by *Pseudomonas viridiflava,* is a problem in the southeastern Unites States onion production areas. The 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.

**Figure 14.** Collapsed leaves caused by bacterial streak

**Figure 15.** Dark green lesions caused by bacterial streak

**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 over-fertilization with N during winter months may reduce losses to bacterial streak. Practices that reduce postharvest rot such as harvesting mature onions, curing onions immediately after clipping, and avoiding bruising or wounding will help avoid disease problems.

## Center Rot

Center rot, caused by *Pantoea ananatis,* 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 has recently been found to be present in many weed species occurring in the Vidalia onion growing 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.

a

b

c

**Figure 16.** Bleached center leaves caused by the center rot pathogen *Pantoea ananatis*

**Management Options**: As with bacterial streak, fixed copper materials tank mixed with EBDC fungicides are recommended to suppress infection and spread. 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.

## 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 degrees F are common.

**Symptoms**: Foliar symptoms, when observed, are similar to 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.

**Figure 17.** Onion bulb deterioration caused by sour skin

**Management Options**: Avoiding overhead irrigation near harvest time will reduce losses to this disease. Use practices that reduce the chance of irrigation water becoming contaminated with the sour skin bacteria. Avoid damaging onion foliage prior to harvest as this provides wounds for the bacteria to enter bulbs. Do not allow mature onions to remain in fields during the warm weather associated with the later harvest season, since infection and spread of this bacterium is enhanced with higher temperatures. Discard infected bulbs before storing as disease can spread from infected bulbs to healthy bulbs. Do not heat cure infected onions post-harvest as this will rapidly spread this pathogen to uninfected bulbs. Storing onions in cool (32 degrees F), dry areas will prevent bulb-to-bulb spread of sour skin.

## Bacterial Soft Rot

Bacterial soft rot, caused by *Erwinia carotovora* pv. *carotovora,* 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 degrees 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.


a

b

**Figure 18.** Deterioration of the core bulb scales caused by bacterial soft rot

**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.

# Viruses

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

Recently these viruses have been detected in onions, but it is unclear if they are 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 and has become a major disease in other onion producing regions, particularly in the western United States and particularly on onion seed crops. IYSV is spread by onion thrips (*Thrips tabaci*), surprisingly not generally found in Georgia. Recently, however, this virus has been detected in Tobacco thrips (*Frankliniella fusca*).

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 if this does occur.

**Symptoms**: There is not enough information available to clearly identify symptoms associated with these virus infections. Small necrotic spots with green tissue remaining in the center may be symptom expression (Figure 19). This has not always been correlated with detection during laboratory screening.

**Management Options**: Since thrips spread these viruses, controlling thrips 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 scout onions in the fall and early winter as well for thrips, taking necessary action when they appear. Since stress may be a factor in symptom development, take care 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 prior to colder temperatures. If cold weather is expected, it may be wise to delay transplanting until the cold has passed.

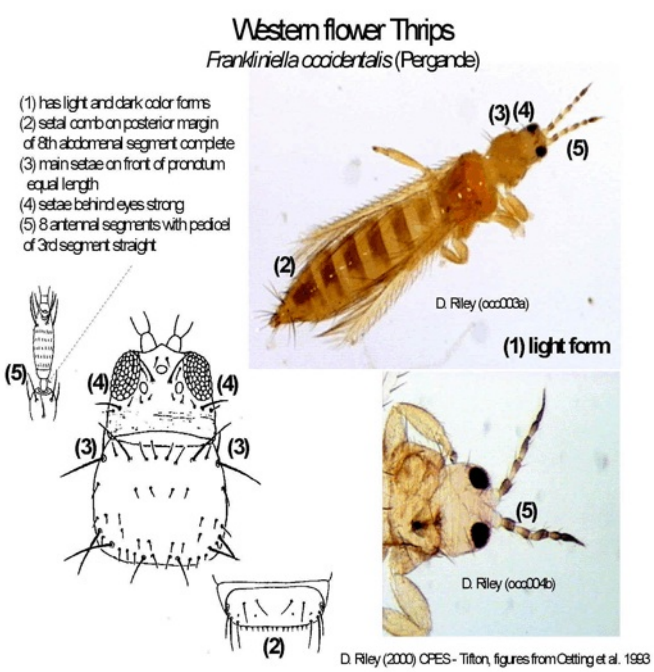


**Figure 19.** Western Flower Thrips

**Registered Fungicides***

**1** mancozeb & maneb
Dithane, Manzate, etc.

**2** chlorothalonil
Bravo, Echo, Equus

**3** iprodione
Rovral

**4** cyprodinil + fludioxonil
Switch

**5** fixed copper

**6** mefenoxam

**7** fosetyl-A1
Aliette

**8** pyrimethanil
Scala

**9** mefenoxam + chlorothalonil
Ridomil Gold Bravo

**10** mefenoxam + copper
Ridomil Gold/Copper

**11** mefenoxam + mancozeb
Ridomil Gold MZ

**12** mancozeb + copper
ManKocide

**13** boscolid + pyraclostrobin
Pristine

**14** boscalid
Endura

**15** dimethomorph
Acrobat

**16** azoxystrobin, pyraclostrobin
Quadris/Amistar, Cabrio

| | *Registered Fungicides | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DISEASE** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** |
| Damping-Off *Pythium* spp. | P | P | P | P | P | G | P | | F-P | F-P | F-P | P | P | P | P | P |
| Onion Smut | E | P | P | P | P | P | P | P | P | P | G | G | U | U | U | U |
| Botrytis Leaf Blight *B. squamosa* | G-F | G | E-G | E-G | F | P | P | G | G | P | G-F | G-F | E | E | P | G |
| Botrytis Neck Rot *Botrytis allii* | P | P | F-P | U | P | P | P | U | P | P | P | P | G | G | P | P |
| Purple Blotch *Alternaria porri* | G | G | E | G | F | P | P | E-G | G-F | P | G-F | G-F | E | E | P | E-G |
| Stemphylium Leaf Blight & Stalk Rot | F | F | E-G | G | P | P | P | E-G | F | P | F | F | E | E | P | E-G |
| Downy Mildew *P. destructor* | G | F | P | P | F | GR | G-F | P | GR | GR | GR | G-F | G | P | GC | G |
| Bacterial Soft Rot *Erwinia carotovora* | P | P | P | P | F | P | P | P | P | F | P | F | P | P | P | P |
| Fusarium Basal Rot | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P |
| Pink Root *Phoma terrestris* | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P |
| Black Mold *Aspergillus niger* | P | P | P | P | P | P | P | P | P | P | P | P | U | U | U | U |
| *Pantoea ananatis* | P | P | P | P | FC | P | P | P | P | FC | P | F | P | P | P | P |
| Bacterial Streak | P | P | P | P | FC | P | P | P | P | FC | P | F | P | P | P | P |
| White Rot | P | P | G-F | P | P | P | P | P | P | P | P | P | P | P | P | U |

Information in this table was partly derived from ratings given at the IR-4 Bulb Vegetable Crop Group Workshop held during the 1999 American Phytopathological Society annual meeting in Montreal, Canada. Ratings for products does not necessarily indicate a labeled use. C = When used in combination with mancozeb. V = Variable levels of control. R = Pathogen resistance (insensitivity) may be present at some locations. E = Excellent disease suppression, G = Good disease suppression, F = Fair disease suppression, P = Poor to no disease suppression U = Unknown efficacy

| Commodity / Disease | Material | Formulated | Amount of Form/Gal of Water | Minimum Days to Harvest | Method, Schedule, Remarks |
|---|---|---|---|---|---|
| | | Rate of Material to Use | | | |
| **ONION (Dry)** | | | | | |
| Plant Bed | Methyl bromide | 350 lb./A. | | | See the label (tarp required). |
| | metam sodium (42%) | 3 7.5-75 gal. | | | See the label. |
| Pythium Damping-Off | Ridomil Gold EC | 1/2-1.0 pt. | | | Incorporate into soil. See the label. |
| Purple Blotch | Pristine [1,3,4] | 10.5-18.5 oz. [1]<br>14.5-18.5 oz. [3]<br>18.5 oz. [3] | | 7 | Apply prior to disease onset and on a 7-14 day schedule. Alternate to a fungicide with a different mode of action after two sprays. Pristine only suppresses downy mildew. |
| Bacterial Leaf Blight | Scala [1, 3] | 9-12 fl oz. | | 7 | Use low-rate of Scala with tank-mix only. |
| Botrytis Leaf Blight | Auadris (Amistar) [1,4] | 6.2-15.4 fl oz. (2.0-5.0 oz.) | | 0 | Apply no more than two sequential applications of Quadris or Cabrio before rotating to a fungicide with a different mode of action. |
| | Cabrio, [1,4] | 8 .0-12.0 oz. | | 0 | |
| Downy Mildew [4] | Ortho Daconil 2787 (H) | | 1.0 Tbs./gal. | 7 | |
| | Ridomil Gold MZ [4] | 2.5 lb. | | 7 | Spray on a 7-14 day schedule depending on weather and disease pressure. |
| | Ridomil Gold/Copper | 2.0 lb. | | 10 | |
| | Ridomil Gold Bravo [1,3,4] | 2 | | 7 | |
| | Bravo Weather Stik [1,3,4] | 1.0-2.0 pt. | | 7 | |
| | Echo 720 [1,3,4] | 1.0-2.0 pt. | | 7 | |
| | Equus 720 [1,3,4] | 1.0-2.0 pt. | | 7 | |
| | Switch 62.5 WG [1,3] | 11.0-14.0 oz. | | 7 | 12-month rotational restriction to crops other than onions or strawberries with Switch. |
| | Dithane DF Rain Shield [1,3,4] | 3.0 lb. | | 7 | |
| | Dithane M-45 [1,3,4] | 3.0 lb. | | 7 | |
| | Dithane DF [1,3,4] | 3.0 lb. | | 7 | |
| | Dithane F-45 [1,3,4] | 2.4 qt. | | 7 | |
| | Maneb 75DF [1,3,4] | 2.0-3.0 lb. | | 7 | |
| | Maneb 80WP [1,3,4] | 2.0-3.0 lb. | | 7 | |
| | Manex [1,3,4] | 1.6-2.4 qt. | | 7 | |
| | Manex II [1,3,4] | 2.4 qt. | | 7 | |
| | Manzate 75DF [1,3,4] | 3.0 lb. | | 7 | |
| | Penncozeb 75DF [1,3,4] | 2.0-e.0 lb. | | 7 | |
| | Penncozeb 80 WP [1,3,4] | 2.0-3.0 lb. | | 7 | |
| | ManKocide [1,2,3,4] | 2.5 lb. | | 7 | |
| | Forum | 6.0 fl oz. | | 0 | Tank-mix Forum with other fungicides. Application of copper compounds may be phytotoxic to leaves. |
| | Kocide 101 [1,4] | 2.0 lb. | | NTL | |
| | Kocide DF [1,4] | 2.0 lb. | | NTL | |
| | Kocide LF [1,4] | 2.6 pt. | | NTL | |
| | Champ 2F [1,2,4] | 1.3 pt. | | NTL | |
| | Champ F [1,4] | 2.6 pt. | | NTL | |

**Vegetable Disease Control (continued)**

| Commodity / Disease | Material | Formulated | Amount of Form/Gal of Water | Minimum Days to Harvest | Method, Schedule, Remarks |
|---|---|---|---|---|---|
| | | Rate of Material to Use | | | |
| | Nu-Cop 50DF [1,4] | 2.0 lb. | | NTL | |
| | Nu-Cop 3L [1,4] | 1.3-2.6 pt. | | NTL | |
| | Cuprofix Disperss [1,4] | 2.5-6.0 lb. | | NTL | |
| | Rovral 4F [1,3] | 1.5 pt. | | 7 | |
| | Aliette [4] | 2.0-3.0 lb. | | 7 | |
| | Reason | 5.5 fl oz. | | 7 | Rotate with non-strobilurins. |
| | Aliette+Maneb [1,3,4] 2+2 | 4.0 lb. | | 7 | If disease pressure high, spray every 14 days. Minimum of three applications. |
| | Dragon Mancozeb Disease Control (H) | | 4 3/4 tsp./gal. | | |
| | Bonide Mancozeb Plant Fungicide (H) | | 4 tbsp./gal. | | |
| Pink Root | Metam sodium (42%) | 37.5-75 gal./A | | | Apply through chemigation or soil incorporate with a roto-tiller device. |
| Bacterial Streak and Bulb Rot Pantoea | Follow recommended cultural practices and disease prevention practices. Copper compounds tank-mixed with EBDC fungicides may reduce disease spread. | | | | |
| **ONION (Green and Green Bunching)** - Garlic, Leek, Shallot, Onion grown for seed | | | | | |
| Botrytis Leaf Blight | Ortho Daconil 2787 (H) | | 1.0 Tbs./gal. | 14 | See the label. |
| Downy Mildew | Maneb 80 WP | 2.0-3.0 lb. | | 7 | See the label. Do not apply to exposed bulbs. |
| Neck Rot | Maneb 75 DF | 2.0-3.0 lb. | | 7 | See the label. |
| Purple Blotch | Manex | 1.6-2.4 qt. | | 7 | See the label. |
| | Ridomil Gold Bravo | 2.0 lb. | | 14 | See the label. |
| | Ridomil Gold/Copper | 2.0 lb. | | 21 | See the label. |
| | Bravo Weather Stik | 1 1/2-3.0 pt. | | 14 | See the label. |
| | Echo 720 | 1 1/2-3.0 pt. | | 14 | See the label. |
| | Equus 720 | 1.5-3.0 pt. | | 14 | See the label. |
| | Reason | 5.5 fl oz. | | 7 | Rotate with non-strobilurins. |
| | High Yield Copper Fungicide (H) | | 2 tsp./gal. | NTL | |
| | Bonide Liquid Copper Fungicide (H) | | 4 tsp./gal. | up to day of harvest | |
| | Dragon Copper Fungicide (H) | | 4-6 tsp./gal. | up to day of harvest | |
| | Dragon Mancozeb Disease Control (H) | | 2 tsp./gal. | 7 | |
| | Bonide Mancozeb Plant Fungicide (H) | | 3 tbsp./gal. | 7 | |

# Onion Insects and Their Control

*Stormy Sparks and David Riley – Extension Entomologists*

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. Preventive measures and careful scouting can minimize or eliminate any potential problems.

Soil-borne insects such as cutworms, onion maggots, wireworms, and others can be controlled with preplant applications of an appropriate soil insecticide (Table 7, page 30). Make application just prior to seeding plantbeds and transplanting to final spacing.

**Onion maggots** (*Delia antiqua*) can be severe pests 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 larva feed on the developing plants. Seed corn maggots can reduce plant stands in seedbeds, as germinating seeds and small seedlings can be killed. Once plants are established, seed corn maggots are not likely to cause plant mortality. They may be associated with dead and decaying plants as these plants are attractive to the maggots, which feed on most decaying plant material. It is also common 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 maggots 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, avoid fields containing high levels of organic matter or take care to thoroughly treat the soil with an appropriate insecticide.

Cutworms, wireworms, and other soil insects are frequently present in fields before planting. These 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 prior to planting or transplanting can reduce problems with soil insects. Where soil insect problems are anticipated, preventive treatment with a preplant insecticide is recommended (Table 7).

**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 generally is detected as plants cut off near the soil line. Their nocturnal habits and cryptic coloration make cutworms 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. See Table 7 for appropriate control measures.

**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 larva feed on below ground portions of plants. While some species have multiple generations in a year, others are capable of living as larvae for 1-2 years before pupating and becoming adults. See Table 7 for appropriate control measures.

**Thrips** are the primary insect pest of onions. Thrips have rasping mouthparts that cause physical damage to the onion leaf. Damaged leaves are more susceptible to subsequent disease infection and are less efficient at photosynthesis. While these insects can appear in the fall, they are much more common in late winter and early spring as temperatures rise. 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, begin careful scouting of plants shortly after the beginning of the year. Give special attention 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.

Begin spraying for thrips when an average of five thrips per plant is present. However, research has indicated that a single spray of an effective insecticide when there is one thrip per plant can reduce subsequent thrip populations and reduce the number of subsequent insecticide sprays. Spraying within 2 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, once the bulb has reached full size, thrips damage is inconsequential to yield. Thrips may however 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 species of thrips may respond differently to specific insecticides. Excessive use of insecticides or of ineffective insecticides only increases the presence of insecticide resistance. When sprays for thrips are made, they should only be made in response to thrips populations exceeding the threshold, and make species identification prior to insecticide selection. It is also important to keep track of which insecticides are currently effective.

There are three species of thrips that are prevalent on onions in the Vidalia region: Tobacco thrips (*Frankliniella fusca*) (Figure 19), Western flower thrips (*Frankliniella occidentalis*) (Figure 20), and Onion thrips (*Thrips tabaci*) (Figure 21). In recent years, the tobacco thrips has predominated the populations in the Vidalia production region, and pyrethroid insecticides have performed well against this species. However, in the 2006-2007 production season, the onion thrips were found to predominate in some areas, and pyrethroid insecticides performed poorly against this species.

In addition to direct damage to onions, thrips serve as vectors of viral diseases and have been implicated in transmission of other onion diseases. As mentioned in the Disease section, scouting and control of thrips may be necessary during the fall and early winter to control potential outbreaks of IYSV and TSWV. Onion thrips, traditionally unimportant in southeast Georgia, are the major transmitting vector of IYSV. If they become more prevalent, the potential for IYSV outbreaks will increase and may require additional control of thrips.

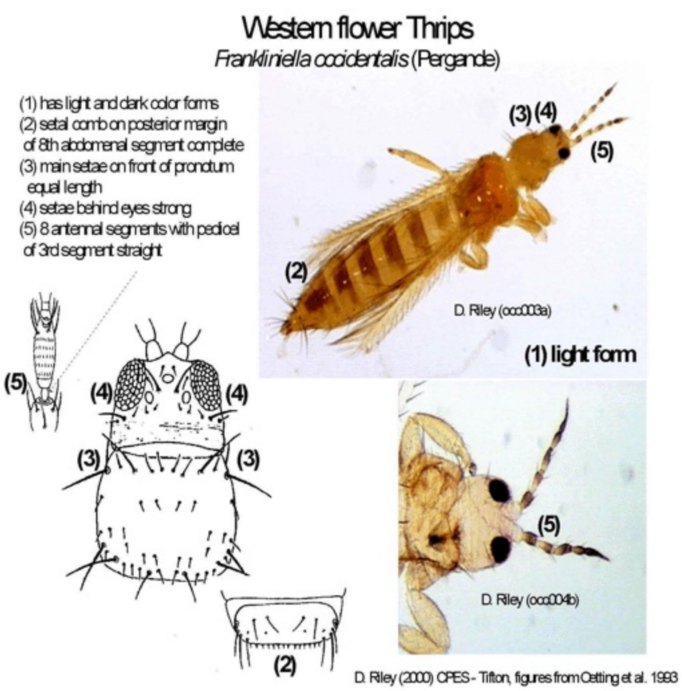


**Figure 19.** Tobacco Thrips

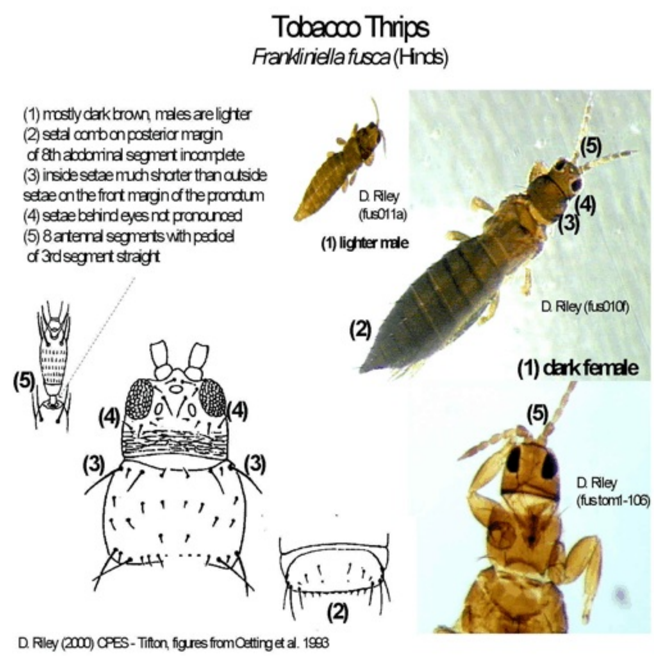


**Figure 20.** Onion Thrips

**Figure 21a.** Onion thrips

**Figure 21b.** Western Flower thrips

**Table 7. Insect control suggestions for onions.**

| Pest | Insecticide | Amount of Formulation Per Acre | Active (lbs.) Per Acre | Harvest Interval (Days) |
|---|---|---|---|---|
| **Pre-Plant or at Planting Treatments** | | | | |
| soil insects, wireworms, seedcorn maggot | chlorpyrifos | | | |
| | (Lorsban) 4E | 1.1 oz. per 1,000 ft of row | | |
| | 15G | 3.7 ozs. per 1,000 ft of row | | |
| | 75WG | 0.73 per 1,000 ft of row | | |
| | diazinon | | | |
| | 4E | 3-4 qts. | 3-4 | |
| | 14G | 21-28 lbs. | 2.94-3.92 | |
| | 50W | 6-8 lbs. | 2-4 | |
| **Foliar Treatments** | | | | |
| Cutworms, seedcorn maggot adults | lambda-cyhalothrin | | | |
| | (Warrior) T | 1.92-3.2 ozs. | 0.015-0.025 | 14 |
| | cypermethrin | | | |
| | (Ammo) 2.5EC | 2-5 ozs. | 0.04-0.1 | 7 |
| | deltamethrin | | | |
| | (Decis) 1.5EC | 1-1.5 ozs. | 0.012-0.018 | 1 |
| | gamma-cyhalothrin | | | |
| | (Proaxis) 0.5 EC | 1.92-3.20 ozs. | 0.0075-0.0125 | 14 |
| | permethrin | | | |
| | (Pounce) 3.2EC | 6-12 ozs. | 0.15-0.3 | 1 |
| | (Pounce, Ambush) 25WP | 9.6-19.2 | 0.15-0.3 | 1 |
| | zeta-cypermethrin | | | |
| | (Mustang Max) 0.8EC | 2.25-4 ozs. | 0.014-0.025 | 7 |
| seedcorn maggot adults | malathion | | | |
| | 8EC | 2 pts. | 2 | 3 |
| | 5EC | 1.5-2.5 pts. | 0.94-1.56 | 3 |

**Table 7. Insect control suggestions for onions (continued).**

| Pest | Insecticide | Amount of Formulation Per Acre | Active (lbs.) Per Acre | Harvest Interval (Days) |
|---|---|---|---|---|
| **Foliar Treatments (continued)** | | | | |
| Tobacco thrips | lambda cyhalothrin | | | |
| *F. fusca* | (Warrior) T 1SC | 2.56-3.84 ozs. | 0.02-0.03 | 14 |
| | cypermethrin | | | |
| | (Ammo) 2.5EC | 4-5 ozs. | 0.08-0.1 | 7 |
| | deltamethrin | | | |
| | (Decis) 1.5EC | 1.5-2-4oz. | 0.018-0.028 | 1 |
| | diazinon | | | |
| | 4E | 1 pt. | 0.5 | 14 |
| | 50W | 1.0 lbs. | 0.5 | 14 |
| | gamma-cyhalothrin | | | |
| | (Proaxis) 0.5 EC | 2.56-3.84 oz. | 0.01-0.015 | 14 |
| | malathion | | | |
| | 8EC | 1-2 pts. | 1-2 | 3 |
| | 5EC | 1.5-2 pts. | 0.94-1.25 | 3 |
| | methomyl | 3 pts. | 0.9 | 7 |
| | (Lannate) 2.4LV | | | |
| | 90SP | 1.0 lbs. | 0.9 | 7 |
| | permethrin | 6-12 ozs. | 0.15-0.3 | 1 |
| | (Pounce) 3.2EC | | | |
| | (Pounce, Ambush) 25WP | 9.6-12.2 ozs. | 0.15-0.3 | 1 |
| | zeta-cypermethrin | 2.88-4 ozs. | .018-025 | 7 |
| | (Mustang Max) 0.8EC | | | |
| Onion thrips | diazinon | | | |
| *T. tabaci* | 4E | 1 pt. | 0.5 | 14 |
| Western flower thrips | 50W | 1.0 lbs. | 0.5 | 14 |
| *F. occidentalis* | malathion | | | |
| | 8EC | 1-2 pts. | 1-2 | 3 |
| | 5EC | 1.5-2 pts. | 0.94-1.25 | 3 |
| | methomyl | 3 pts. | 0.9 | 7 |
| | (Lannate) 2.4LV | | | |
| | 90SP | 1.0 lbs. | 0.9 | 7 |

**Thrips**
NOTE: Insecticide resistance is a recurrent problem with thrips control. Reliance on any single chemistry can result in rapid development of resistance in thrips.

# Onion Weed Management

*A. Stanley Culpepper – Extension Agronomist, Weed Science*

Managing weeds is critical for successful onion production. Effective weed control is often more difficult to obtain in onion than in many other crops because onion grows more slowly and is less competitive with weeds. Additionally, the crop is exposed to both summer and winter annual weeds requiring a weed management program that controls a multitude of very different weed species.

Weeds compete with onions for light, nutrients, water, and space. In addition to reducing harvestable bulbs through competition, weeds interfere with the harvesting process by decreasing hand-harvesting and machine harvest efficiency. Weeds can also harbor destructive insects and diseases that can severely damage the present or following crop. Research has noted that bacterial streak and bulb rot (caused by *Pseudomonas viridiflava*) can use several weeds as alternate hosts including cutleaf evening-primrose, dandelion, purple cudweed, spiny sowthistle, Virginia pepperweed, and wild radish. Controlling these weeds may suppress or reduce bacterial streak and bulb rot levels.

Several weed species commonly infest onion. The most common and troublesome are highly influenced by planting time. It is more likely that summer annual weeds will impact management decisions when onions are planted earlier in the fall season. As planting is delayed, summer annual weeds become less of a concern. Summer annual weed species that will most likely impact onion production include Texas panicum, sicklepod, nutsedge, pigweed, purslane, morning glory, crabgrass, and Florida pusley. Infestations of winter weeds often include cutleaf evening-primrose, swinecress, henbit, Virginia pepperweed, shepherd's-purse, wild radish, and common chickweed.

## Methods of Weed Management

Weed control options are often limited in vegetable crops such as onion. The best methods for an individual grower will depend on several factors such as weed species present, onion row spacing, labor costs, and labor availability.

### Crop Rotation

Crop rotation aids in managing weeds as well as many other pests. Annual and perennial grasses are relatively easy to control in onion through the use of various herbicides. However, controlling certain broadleaf weeds and nutsedge species is often more difficult. Control of difficult weeds may best be obtained through rotating into another crop where these problematic weeds can be controlled more easily and effectively. In addition, rotation to other crops allows the application of different herbicides on the same field in different years. Thus, the grower can reduce or prevent buildup of problem weeds and help keep the overall weed population at lower levels.

### Hand Weeding

Hand weeding effectively controls most weed species. In order to reduce crop damage and to allow for the use of mechanical tools such as hoes, conduct hand weeding when both the crop and weeds are small. Removal of large weeds with extensive root systems may damage crop roots or foliage. Although hand weeding is very effective, it also may be very expensive because of time and labor requirements.

### Stale Seedbed Weed Management

The stale seedbed technique employs a non-selective herbicide such as paraquat or glyphosate to kill emerged weeds before planting the crop. In the stale seedbed method, the bed is prepared several weeks before planting. The 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 cultivation of the desired area several times as weeds emerge before planting.

### Fumigation

Fumigation can provide substantial weed control but is expensive and must be applied by trained personnel. To ensure proper fumigation, the soil is often covered with a non-porous material such as plastic or it is sealed in with a roller (or other packing device) followed with consistent irrigation for several days. Appropriate soil conditions including no soil clods, moisture at field capacity or slightly wetter, and soil free of debris including plant material is absolutely essential for an effective fumigation. The length of time needed for the fumigant to be sealed in the soil varies; read and follow restrictions provided on the label of the product used. Many small-seeded broadleaves and grasses will be controlled, but control of weeds with larger seeds such as morning glories and nutsedge tubers is much more erratic. Fumigation practices have been very successful controlling weeds when applied properly. However, unless fumigation is needed for disease or nematode control, fumigating is often not economical except in seedbeds or seeded onion production.

Application of metam-sodium (Vapam) at 37.5-75 gallons per acre (15.7-31.5 pounds ai) prior to direct seeding plantbeds or seeded onion production is an effective treatment in combination with other herbicides to reduce weed infestations. The waiting period from fumigant application till seeding is very important because a residual fumigant can affect seed germination; review labels for these plant-back intervals.

## Chemical Weed Management

### Planning Your Herbicide Program

Prior to selecting your herbicide program, determine soil characteristics (such as soil organic matter and texture), herbicide capabilities and limitations, herbicide application methods, fumigation application methods, and existing weed species.

Prior to herbicide selection in a crop, consider rotational carry over restrictions. Many herbicides used in crops rotated with onion do not pose a threat of carry over to onion. However, always read labels for rotational restrictions.

### Mapping

Knowing which 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. The 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, you can detect shifts in weed populations and make adjustments in herbicide programs to manage these weed shifts as they occur. Proper weed identification is necessary since weed species respond differently to various herbicides.

### Monitoring

Monitor fields periodically to identify the need for postemergence herbicides. Even after herbicides are applied, continue monitoring to evaluate the success of the weed management program and to determine the need for additional control measures.

## Herbicide Options for Dry Bulb Onion

### Recommendations from 2006-2007 Herbicide Labels

Preplant applications of paraquat or glyphosate can be made to control emerged weeds prior to planting. Paraquat is a contact herbicide used to control small weeds that are less than 2-4 inches in size but will often only burn plant foliage of larger weeds with an eventual plant regrowth. Glyphosate is also a non-selective herbicide that controls most weed species when timely applications are made. Glyphosate will not effectively control cutleaf evening-primrose or glyphosate-resistant pigweed species.

**Dacthal (DCPA)** can be used preemergence at 6-8 pounds of product per acre for control of preemergence annual grasses and small-seeded broadleaf weeds. In Georgia, the rates of Dacthal labeled for seeded onion are often greater than recommended (4-6 pounds of product per acre) because of the potential for onion stunting with the higher labeled rates. Split applications of Dacthal can be made. Contact your local county Extension office for the latest details. Dacthal is recommended for seeded onion production but other, more effective and economical options are available for transplant onions.

**Prowl or Pendimax (pendimethalin)** can be applied postemergence to onions, but prior to weed germination for control of annual grasses such as crabgrass, crowfootgrass, and Texas panicum as well as broadleaf weed species such as common chickweed, pigweeds, Florida pusley, and cutleaf evening-primrose. Apply pendimethalin to direct-seeded onion in the 2- to 9-leaf stage of growth. If no rainfall occurs within 3 days after application, irrigate with approximately 0.5 inch of water. In transplant onions, apply pendimethalin from 2 days after transplanting up to 2 weeks after transplanting. In both seeded and transplant onions, program approach using both pendimethalin and Goal is recommended.

**Goal (oxyfluorfen)** controls many annual broadleaf weeds through postemergence and residual activity. Apply Goal in onion fields to effectively control wild radish, swinecress, shepherd's-purse, cudweed, and evening-primrose. Emerged primrose is often difficult to control with Goal; however, Goal applied prior to primrose emergence is usually very effective.

For seeded onion, use low rates of **Goal 2 XL** (approximately 3-4 ounces per acre (A) or 0.05-0.06 pounds ai per acre on a broadcast basis) and apply to onion in the 3- to 4-leaf stage. When onion has four or more true leaves, Goal 2 XL rates can often be increased to 6-8 ounces per acre. For Goal to be effective against cutleaf evening-primrose, the weed should not be any more than 0.25 inch in diameter.

For transplanted onion, apply up to 2.0 pints per acre (0.5 pounds per acre) of **Goal 2 XL** broadcast to transplants any time between 2 days and 2 weeks after transplanting, as transplanted onions are most tolerant of postemergent application immediately after transplanting. Do not apply Goal with a surfactant, fertilizer, or other chemical. Typically, losses of Goal to volatilization and onion injury from this volatilization are low; however, volatilization has been noted when an application of Goal is followed by a rainfall or irrigation and then a bright, humid, sunny environment.

Recently, Chateau obtained a label for use in transplant dry bulb onion. Do not apply this product in seeded onion as severe injury will occur. For transplant onion growers, apply Chateau at 1 ounce per acre within 2 weeks after transplanting. This product provides excellent residual control of primrose, radish, chickweed, henbit and many other broadleaf weeds. Chateau does not provide grass control but you can mix **Prowl H20** (must be Prowl H20) with Chateau for improved control of a diverse weed spectrum.

**Fusilade DX (fluazifop-P), Poast (sethoxydim), and Select (clethodim)** can be used in onions to control annual grasses such as ryegrass, Texas panicum, crabgrass species, and sandbur as well as perennial grasses such as johnsongrass and bermudagrass. All of these products are safe on onion and control most grasses well. Select and Poast, however, tend to be more effective over a range of annual grass species and environmental conditions, while Select and Fusilade DX are often more effective on perennial grasses. Tank mixing broadleaf herbicides such as Goal with these postemergence grass-control herbicides is not recommended. The addition of crop oil concentrates or non-ionic surfactants is recommended with each grass herbicide - see labels for specific rates.

| Crop/ Application Timing | Weed | Formulation | Rate Per Acre Broadcast: Amount of Formulation | Rate Per Acre Broadcast: Pounds Active Ingredient | Remarks and Precautions |
|---|---|---|---|---|---|
| **Onions (Dry bulb and Green)** | | | | | |
| Preplant | Suppression or control of most annual grasses and broadleaf weeds, full rate needed for nutsedge control | metam sodium (Vapam HL) 42% | 37.5 to 75 gal. | 15.7 to 31.5 | Apply when soil moisture is at field capacity (50-80%). Apply through sprinkler irrigation or through soil injection. For soil injection either incorporate using a rotary tiller or inject with knives no more than 4" apart; follow immediately with a roller to smooth and compact the soil surface or with mulch. May be applied through drip irrigation prior to planting a second, third, or fourth crop on mulch. Plant back interval is at least 14-21 days and can be 30 days in some environments. See label for all restrictions and additional information. |
| | Contact kill of all green foliage; stale seedbed application | paraquat (Gramoxone Max, Firestorm) 3 SL<br><br>(Gramoxone Inteon) 2SL | 1.5 to 2.7 pt.<br><br>2.5 to 4.0 pt. | 0.56 to 1.0 | Seeded Onion Only. Apply to emerged weeds in 20-100 gals. of water before crop emergence. Form rows several days to 2 weeks ahead of treating for maximum weed emergence. Plant with minimal soil movement. Add nonionic surfactant at 1-2 pts. per 100 gals. spray mix or 1 gal. approved crop oil concentrate per 100 gals. spray mix. |
| | Annual and perennial grass and broadleaf weeds, stale seedbed application | glyphosate (numerous brands)<br>4 SL<br>5 SL<br>5.5 SL<br>6 SL | <br><br>1 to 3 pt.<br>0.8 to 2.4 pt.<br>11 to 32 fl oz.<br>10 to 30 fl oz. | 0.5 to 1.5 | Apply to emerged weeds before seeding or 3 days before transplanting. Perennial weeds may require higher rates. Some formulations may require additional adjuvant. |
| **Onions (Dry bulb only)** | | | | | |
| Preplant or Preemergence | Annual grasses and small-seeded broadleaf weeds | bensulide (Prefar) 4 E | 5 to 6 qt. | 5 to 6 | Apply preplant incorporated or preemergence after planting. With preemergence treatment, irrigate immediately after application. Prefar may reduce onion vigor under unfavorable weather conditions. See label for more directions and rotational restrictions. |

| | | | Rate Per Acre Broadcast | | |
|---|---|---|---|---|---|
| **Crop/ Application Timing** | **Weed** | **Formulation** | **Amount of Formulation** | **Pounds Active Ingredient** | **Remarks and Precautions** |
| **Onions (Dry bulb only continued)** | | | | | |
| Preemergence | Annual grasses and small-seeded broadleaf weeds | DCPA<br>(Dacthal)<br>W-75<br>6 F | <br><br>≤ 6 to 8 lb.<br>≤ 6 to 8 pt. | ≤ 4.5 to 6 | Apply immediately after seeding. For seeded onion production contact your local Extension office for the most effective weed program using DCPA.<br><br>High rates applied after seeding onion may cause crop stunting and maturity delay. **Lower than labeled rates may be needed when growing under intense watering, contact Extension office.** |
| Postemergent | Residual control of annual grasses and small-seeded broadleaf weeds including purslane | pendimethalin<br>(Prowl) 3.3 EC<br>(Pendimax) 3.3 EC<br>(Prowl $H_20$) 3.8 AS | <br>1.2 to 2.4 pt.<br>1.2 to 2.4 pt.<br>1.0 to 2.0 pt. | <br>0.5 to 1<br>0.5 to 1<br>0.48 to 0.95 | **Seedbed or direct seeded:** Apply when onions have two to nine true leaves but prior to weed emergence.<br><br>**Transplants:** Apply to onions after soil has settled (watered) around transplants and no cracks are present. If no rainfall occurs within 3 days after application, irrigate as needed.<br><br>Do not apply within 45 days of harvest. Does not control emerged weeds. |
| | Most annual broadleaf weeds including henbit, swinecress and very small primrose but much less effective on chickweed | oxyfluorfen<br>(Goal 2 XL) 2 EC<br>(Galigan) 2 E<br>(Goaltender) 4L | <br>3 to 32 fl oz.<br>3 to 32 fl oz.<br>1.5 to 16 fl. oz. | 0.05 to 0.5 | **Seeded 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 and when weeds are approximately 1" in dia-meter. Sequential applica-tions may be made but do not exceed 2.0 pt./A/season of Goal 2 XL (1.0 pt./A for Goal-tender). Do not apply prior to 2 true leaves or under wet, cool conditions. Label recommends use of 8 oz./A of Goal 2XL, however injury from this appli-cation can be severe if onion is in the 2, 3, or 4-leaf stage.<br><br>**Transplanted onions:** Make a single application using up to 2.0 pt./A of Goal 2XL (1.0 pt./A of Goaltender) within 2 days of transplanting, do not wait longer than 2 days to make this appli-cation. If less than these *(Continued on next page)* |

| Crop/ Application Timing | Weed | Formulation | Rate Per Acre Broadcast: Amount of Formulation | Rate Per Acre Broadcast: Pounds Active Ingredient | Remarks and Precautions |
|---|---|---|---|---|---|
| **Onions (Dry bulb only continued)** | | | | | |
| | | | | | *(Continued from previous page)* rates are applied, a second application can be made 2 weeks or more after trans-planting. Do not exceed 2 pt./A of Goal 2XL (1 pt./A of Goal-tender) total.<br><br>**NOTE:** Never use surfactant or crop oil with oxyfluorfen or serious onion damage may occur. Do not apply if onions are under stress. Do not apply within 60 days of harvest. Do not tank mix with fertilizer. |
| | Most winter annual weeds including primrose | flumioxazin (Chateau) 51 WDG | 1.0 oz. | 0.032 | **Transplants Only.** Apply within 2 weeks after transplanting. Do not apply more than 1 oz./A. Do not include any adjuvant. Can tank mix ONLY with Prowl H20 at labeled rates.<br><br>**Tank clean out is a serious issue with this product.** Sprayer must be cleaned **every day** after use. It's suggested not to use this sprayer to make any topical application to other crops. |
| | Annual and perennial grasses only | clethodim (Select) 2 EC<br>(SelectMax) 0.97 EC | 6 to 16 fl oz.<br><br>12 to 32 fl. oz. | 0.09 to 0.25 | Apply to actively growing grasses. For Select, add 1 gal. crop oil concentrate per 100 gal. spray mix. Adding crop oil may increase the likelihood of crop injury at high tempera-tures. For SelectMax, add 1qt. non-ionic surfactant per 100 gal. spray mix. Do not apply within 45 days of harvest. Use higher rate for larger grasses and for perennial control. **Do Not** apply with other herbicides. Effective on annual bluegrass. |
| | | fluazifop-p (Fusilade DX) 2 EC | 6 to 16 oz. | 0.1 to 0.25 | Apply to actively growing grasses. Add 1 gal. crop oil concentrate or 1 qt. nonionic surfactant per 100 gal. spray mix. Adding crop oil may increase the likelihood of crop injury at high temperatures. Do not apply within 45 days of harvest. |

| Crop/ Application Timing | Weed | Formulation | Rate Per Acre Broadcast<br>Amount of Formulation | Pounds Active Ingredient | Remarks and Precautions |
|---|---|---|---|---|---|
| **Onions (Dry bulb only continued)** | | | | | |
| | | sethoxydim<br>(Poast) 1.53 EC | 1 to 1.5 pt. | 0.19 to 0.3 | Apply to actively growing grasses. Add 1 qt. of crop oil concentrate per 100 gal. spray mix. Adding crop oil may increase the likelihood of crop injury at high temperatures. Do not apply within 30 days of harvest. |
| **Row Middles Only** | | | | | |
| Hooded spray | Most emerged weeds | glyphosate<br>(numerous brands)<br>4 SL<br>5.5 SL | 16 to 30 fl oz.<br>11 to 22 fl oz. | 0.5 to 0.94 | Apply as 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. |
| | Annual broadleaf weeds including morning glory, pigweed, and spiderwort | carfentrazone<br>(Aim EC) 2.0 EC<br>(Aim EW) 1.9 EW | .5 to 2 fl oz. | 0.008 to 0.031 | Apply as a hooded spray in row middles. Do not allow herbicide to contact the crop. Apply to weeds less than 3". Coverage is essential for weed control. Add a non-ionic surfactant at 1 qt. per 100 gal. of spray mix. May mix with glyphosate. Ground speed should not exceed 3.5 mph. |

# Harvesting, Curing And Storing

*Paul E. Sumner – Extension Engineer*
*William C. Hurst – Extension Food Scientist*

Bulb quality is the most important factor when producing a marketable product. To ensure maximum quality, artificially cure onions. Artificial curing allows the grower better control over the curing process. During years when excessive rains and unfavorable drying conditions occur in the field, artificial curing will be required.

## Harvesting

Harvest onions 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 day length sensitive and 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 percent 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 fallen over is not a true indication of maturity, since the tops can be knocked over by strong winds or rain, they may become limp from lack of moisture. Carefully examine onions for softness in the neck and large bulb size to indicate 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.

Undercut onions with a rotating bar or fixed blade when mature and necks are soft and limber. The blade or rotating bar should operate at approximately 1 inch below the bulb, so as not to damage their bases. 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. Make every effort to prevent excessive bulb exposure to the sun, which will cause the onion to blister. Gather onions within a few days of undercutting. If light rain occurs during field drying, undercut the onion beds a second time. This will break soil that has re-attached to the bulb.

After onions have field dried for 3-5 days under sunny dry conditions, remove the roots and tops of the onions. Tops are cut at approximately 1.5-2 inches above the bulb and roots cut off completely. Extra short necks increase the likelihood of disease infection. During clipping, take care 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 are usually placed into burlap or mesh bags in the field and transported by truck to packing sheds. Always handle onions carefully to avoid external and internal damage, especially when loading onto the hard surface of truck bodies. Avoid walking and standing on bags of onions. Place the bulbs in bins or boxes with at least 6 percent vent space. Immediately place the bins 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 3-5 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 that removes the remainder of the tops left by the harvester. Neck length is approximately 1-1.5 inches. 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 in order 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 percent) 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 properly cured, 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. Maintain the air temperature between 97-100 degrees F. The airflow should be 365-1,030 cfm (circulating forced air) per ton of sweet onions. Linear air velocity should be 15-21 feet per minute through the stack of onions. The less airflow capacity, the longer it will take to cure the onions. Relative humidity should be maintained at approximately 50-65 percent. Two types of artificial curing systems being used are batch and recirculating forced air.

Batch curing is the most common type of curing system, consisting of heating 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 conditions of the outside air vary. For batch curing with an airflow rate of 780 cfm per ton of onions with a 35 degrees F rise in air temperature, the heater should have the capacity of 30,030 BTU per hour per ton of onions. To allow air movement away from the onions, an air space of 25' above the top bins is required.

Recirculating 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 recirculating air curing is 3,500 BTU per hour per ton of onions. These calculations are based on minimum 65 degrees F environmental temperature and 99 degrees F curing chamber temperature.

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. Close off the fork lift space below bins and the handle areas of boxes with strips of plastic or canvas to stop airflow through these areas. When air is being pushed through the containers, use a more rigid material like wooden panels. Place the fan framing tightly against the containers to eliminate any loss or escape of air (Figure 22).

Onions are generally cured for 24-48 hours prior to final grading and packing. This may vary depending on the condition of the onions. Sort and inspect onions immediately following curing before shipping or storage. If the onions are left unattended for more than one week, inspect them 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 four weeks of harvest. Onions destined for cold or CA storage should be sampled and analyzed for disease before storage in order to remove infected bulbs.

There is no point in storing onions that are already infected.

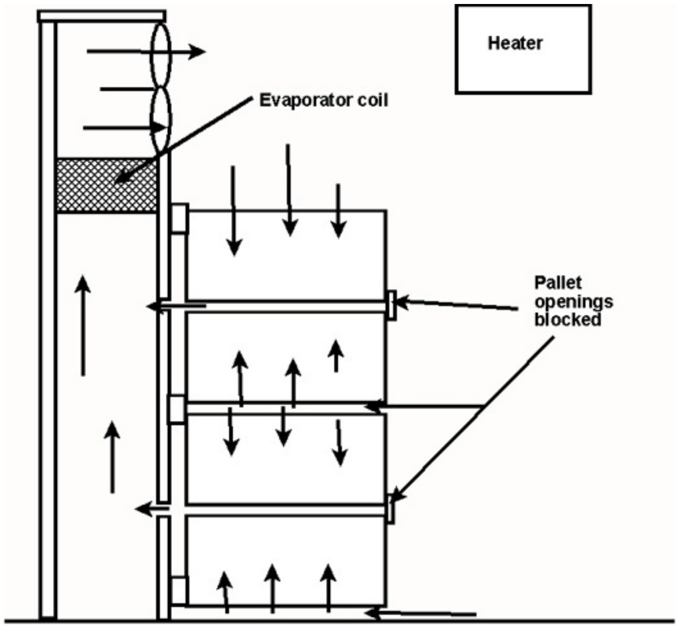


**Figure 22.** Onion curing

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 under-cutting. Exercise care with this process since onions are subject to sun damage if left in the field too long. Late maturing and late harvested onions can be more prone to late season warm weather bacterial diseases such as sour skin and slippery skin. Exercise care not to harvest such onions. Particularly during curing, do not commingle infected onions with uninfected onions. 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 on to the market following the fresh market window may be kept in cold storage, but place them into cold storage within one 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 made 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, causing 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 onions' 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 resulting in less bruising. Unloading is but 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.

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-pound 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:

- Harvest only mature onions.
- Do not over fertilize onions.
- Withhold nitrogen fertilization 30-45 days before harvest and irrigation 1-2 weeks before harvest.
- 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 USDA inspectors in order 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 8, page 45). For more complete information on grading Granex onions, obtain the *United States Standards for Grades of Bermuda-Granex-Grano Type Onions* from the USDA. This publication is also available on the web at www.ams.usda.gov/standards/. The USDA grade standards list a “small” (1-2.25 inches) and “pre-packer” (1.75-3 inches) grade size, but these are never marketed as Vidalia onions.

### Control Atmospheric Storage Requirements

Cold storage conditions recommended for onions in the *USDA Handbook 66* are a temperature of 32 degrees F and a relative humidity of 65-70 percent. The handbooks indicate a RH of 85 percent has been satisfactory with forced air circulation.

Research shows properly cured and decay-free sweet onions stored in a controlled atmosphere (CA) containing 5 percent carbon dioxide, 3 percent oxygen, and 92 percent nitrogen for up to 7 months at 34 degrees F, 70-85 percent RH. These onions had good quality and shelf life when removed from CA storage.

There are several conditions that must be met for a CA facility to work properly. The building must be air- and moisture-tight. Several types of building construction are suitable for CA storage rooms.

The construction must provide:

- An absolute vapor barrier to prevent moisture migration into the CA room.
- Adequate insulation (25-30 R-walls, 30-40 R-ceiling).
- Air-tight conditions (the room should hold one-half pressure {pressure change from 0.8" to 0.4" or from 0.6" to 0.3" of water} ). A leaky room will require excessive nitrogen and carbon dioxide additions. Leaks around the door and improperly sealed penetrations are major contributors to a poorly sealed room.
- Protect the CA room from wind and direct contact with sunlight and rainfall to prevent extremely rapid changes in temperature that may cause rooms to leak.
- Each room must have a vacuum-pressure release valve and be equipped with an air bag to prevent atmosphere loss when minor fluctuations in room pressure occurs. A large air bag may be needed for onion CA rooms due to large air volume increase during evaporator defrost cycle.
- Interconnect rooms(with PVC piping and valves) to allow more efficient CA establishment and pressure normalization. Room interconnections are especially important for small rooms.
- Calculations show that a large CA door (12.5' X 16') can increase room capacity by 400-600 bags and rapidly offset the additional cost of the larger door.

The storage temperature must be maintained at 34 degrees F. Some portions of sweet onions may freeze at 30.8 degrees F. Freezing damage appears as water soaked outer scales when thawed onions are cut. A temperature of 34 degrees F with variations of 1 degree F or less should prevent freezing. Each storage room should have at least two evaporator units with one condenser unit (sized to meet room heat gain) equipped with reheat. Stagger the defrost cycles of the evaporators with room PVC piping interconnections among rooms to serve as atmosphere expansion/contraction buffers. A back-up cooling system may be advisable.

Maintain air storage circulation at 100-200 cfm per ton of onions. Forced air circulation is needed to keep temperature and relative humidity conditions uniform throughout the CA room. Fans should be placed at the rear of the room (opposite from entrance door), draw air through the pallet openings of the bins into a plenum area, and then blow it over the cooling and dehumidification units attached through the roof of the CA room. Stack bins to ensure continuity of the pallet box forklift openings for the entire length of the stack in line with airflow. Variable fan speed controls will help attain uniform RH conditions throughout the room. Begin operating fans when the first onions are placed into each room and continue until the last onions are removed.

Maintain relative humidity at 70-75 percent. Sweet onions will lose weight in CA storage at a rate of 1-1.5 percent per month. In a 10,000 bag storage room, this represents a water generation rate of 5,000-7,500 pounds per month or 7-10 pounds per hour. The dehumidification system must be capable of removing this amount of water without significantly affecting storage temperature. Operation of dehumidification units is controlled by a humidistat. Improper control of relative humidity, air circulation, and temperature can cause a complete loss of sweet onions during storage.

Maintain the oxygen concentration at 3 percent in the room. The low oxygen level is attained by flushing the room with nitrogen gas. Nitrogen can be obtained by on-site generation with a membrane, a pressure swing absorption $N_2$ generator, or through use of liquid nitrogen. All three sources of nitrogen gas have been used effectively for CA storage. A low oxygen level reduces respiration and sugar loss and prolongs the storage life of onions. This low oxygen environment is extremely dangerous to humans. In this atmosphere, humans can lose consciousness in less than 30 seconds, and breathing and heartbeat will stop within minutes. **Do not enter a CA room that will not support a flame (16-17 percent oxygen) without breathing apparatus**. (See Safety Precautions for Controlled Atmosphere Storage.)

Maintain the carbon dioxide concentration at 5 percent in the room atmosphere. Carbon dioxide can be supplied in cylinders and metered into the room as needed. This carbon dioxide atmosphere inhibits respiration and pungency development, and prolongs storage and post-storage shelf life. Carbon dioxide production by the onions will not likely be enough to develop and maintain a level of 5 percent unless the room is sealed extremely tight. In any event, the carbon dioxide levels should be monitored and not allowed to go above 7 percent as this will cause translucent scale to develop.

It is essential to monitor temperature, humidity, and gas atmosphere in the CA rooms without entering them. Monitor readings at least twice daily. Measure temperatures in the warmest and coldest areas of the room, with an alarm for high and low temperatures and set point deviations to avoid heat or cold damage to the onions. Monitor oxygen and carbon dioxide concentration and make adjustments manually or automatically with a computerized system. Relative humidity sensors located in the front and rear of the room are used to monitor RH differences. The RH sensors should be able to function for at least six months without re-calibration. When RH differences in front and rear (plenum) are excessive, increase the air-circulation fan speed. This fan speed adjustment can also be made manually or automatically with a computerized system. Maintain a record of all measurements and adjustments.

Ideally, CA rooms would have the temperature raised before equilibrating the atmosphere with outside conditions. This is impractical under commercial conditions where onions will be removed from CA rooms over several weeks. Under these conditions, it is best to maintain refrigeration after atmosphere equilibration. Onions must be warmed immediately after removal from CA storage to prevent moisture condensation (sweating) on the bulbs. This can be accomplished by blowing air over the onions to prevent condensation as they warm under ambient conditions. If supplemental heat is used for warm-up, the difference between air temperature and bulb surface temperature should not exceed the dew point (about 15 degrees F).

The room size should reflect the distribution and marketing rate of the onions. In general, each room should hold the volume of onions to be sold in one week. If weekly sales are less than the capacity in one room, arrangements must be made to warm onions outside the CA room. Removal of a portion of the onions from a CA room will reduce shelf life and quality of the remaining onions if CA conditions are not reestablished. Regeneration of the CA atmosphere may be prohibitively expensive with large void volumes (partially-filled rooms).

Sell the onions quickly after the warm-up procedure begins. Shelf life losses after removal from CA can be as high as 30 percent after 2 weeks. Sweet onions must have good air circulation throughout marketing to prevent root decay and surface mold growth.

### Safety Precautions For Controlled Atmosphere Storage

When CA facilities are opened for maintenance or unloaded, allow time to let oxygen levels in the air build up to 21 percent. Normal CA practices for onions dictate that oxygen levels are less than 3 percent during storage. If you need to enter a sealed CA room before oxygen levels reach 21 percent, proceed as follows:

- Never enter a sealed CA room without another person present to observe or assist. Have two sets of tested breathing apparatus ready. Feed the breathing equipment with air not pure oxygen. Hold the mask in place with straps. Scuba-diving equipment is dangerous to use because the mouthpiece may drop from your mouth if you fall. Check the breathing apparatus, make sure it delivers air to the mask and that the tank is full of air.
- Inexperienced individual(s) using equipment for the first time should put on the breathing equipment under normal conditions and use up a tank of air outside the CA room while doing routine tasks. They can then become accustomed to the apparatus, learn something about its limitations, and hear the alarm when the air level in the tank is nearly exhausted. Refill the tanks prior to use in the CA storage area. When a person enters the CA room with a breathing apparatus, the backup person must keep that person in sight. If needed, the backup person should follow the first into the room (wearing breathing equipment). If both people are in the CA room and a warning bell rings to signal the tank is almost empty, both people should exit the CA room. Be sure you understand the symptoms of asphyxia before entering a sealed CA room (Table 9, page 45). **Do Not Take Any Chances!**

### Cold Storage of Short-day Onions

Onions that are not marketed immediately can be stored for short periods under refrigeration (34 degrees F for up to one month). Refrigeration will minimize losses in onions held for short periods before moving on to retail markets. Exercise care 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 percent, 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 build-ups of $CO_2$. This is particularly important in rooms not being accessed on a regular basis, 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 self-life after removal from storage. Research shows CA stored onions can lose 30 percent of their marketability in just two 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. Retailers should consider point of sale displays that educate consumers about the importance of refrigerated storage.

**Table 8. USDA size grades for Bermuda, Granex, and Grano type onions.**

| Grade Size | Minimum Diameter (inches) | Maximum Diameter (inches) |
|---|---|---|
| Medium | 2 | 3.25 |
| Large or Jumbo | 3 | No requirement |
| Colossal | 3.75 | No requirement |

**Table 9. Effects of low oxygen environments**

| Oxygen Level | Effects |
|---|---|
| 21% | Breathing, all functions normal. |
| 17% | Candle is extinguished. |
| 12-16% | Breathing is increased and pulse rate accelerated. Ability to maintain attention and think clearly is diminished, but can be restored with effort. Muscular coordination for finer skilled movements is somewhat disturbed. |
| 10-14% | Consciousness continues, but judgment becomes faulty. Severe injuries (burns, bruises, broken bones) may cause no pain. Muscular efforts lead to rapid fatigue, may permanently injure the heart, and may induce fainting. |
| 6-10% | Nausea and vomiting may appear. Legs give way, the person cannot walk, stand, or even crawl. This may be the first and only warning sign, coming late. The person may realize they are dying, but they do not care. It is all quite painless. |
| 0-6% | Loss of consciousness in 30-45 seconds if resting, sooner if active. Breathing in gasps, followed by convulsive movements, then breathing stops. Heart may continue beating, but will stop in a few minutes. |

# Food Safety Practices

*William Hurst – Extension Food Scientist*

Outbreaks of food-borne disease caused by human microbial pathogens on fresh produce are still rare. But since more Americans are eating fresh fruits and vegetables, the number of outbreaks is increasing. Several highly publicized outbreaks in recent years caused the USDA and the FDA in 1998 to jointly publish the first-ever safety document, *The Guide to Minimize Food Safety Hazards for Fresh Fruits and Vegetables,* for the fresh produce industry. It defines safe agricultural practices for growing, harvesting, packing, and shipping fresh produce.

Onion growers and shippers should take a proactive role in minimizing the food safety risks for their crops. There is at least one documented case (Cook, 1995) of a multi-state, food-borne outbreak of the disease "shigellosis," attributed to the consumption of green onions (scallions) contaminated with the fecal human pathogen *Shigella dysentiae*. If fecal pathogens can survive on green onions, they can be harbored by Vidalia onions. Onions themselves do not allow pathogens to multiply because they contain a natural anti-microbial agent called Allicin, but onions can be the source of an infection by cross-contaminating other products. Low levels of pathogens carried on onions can cross-contaminate other produce served on salad bars, or pizza, or in relish products, creating the opportunity for pathogen growth and human infection.

### Onion Quality and Safety

Most consumers perceive onion quality and onion safety as meaning the same thing, but there is actually no relationship between the two. Good quality onions may appear visually appealing and taste sweet, yet contain human fecal pathogens. Unlike plant pathogens, these microorganisms will not cause spoilage signs. In contrast, marginally acceptable onions may appear unappealing yet present no health hazard to the consumer. Remember, the safety of onions cannot be determined by their outward appearance or condition. The best guarantee of a safe raw product is a proactive food safety program designed and implemented to identify and prevent hazards during production and post-harvest handling of these vegetables.

## Field Sanitation Program

### Raw Product Safety

Ensuring fresh onion safety begins with preventing hazards in the field. Growers/shippers should familiarize themselves with safe production practices. Some issues of concern during fresh production are summarized in Table 10 (page 48).

### Land Use History

Grazing animals on or near cropland can introduce pathogenic bacteria to the soil that can be harmful to humans. Growers should ensure the land has not been used for animal husbandry and that it is not in proximity to animal feedlots or water runoff from grazing lands. Improper use of pesticides can result in hazardous residues on raw product. Buyers might insist on letters of guarantee from growers/shippers that the land is suitable and safe for the crops being produced. Before planting, determine soil residue levels of pesticides and heavy metals.

### Fertilizer Use

Incompletely composted organic fertilizers may contain harmful bacteria derived from animal or human feces, specifically *Escherichia coli* (*E. coli*). *E. Coli* is very persistent in manure and is not destroyed until compost temperatures reach 70 degrees C (about 158 degrees F). Based on our best evidence, which is still incomplete, the application of fresh manure to land should allow for at least four months of contact time before crops are harvested.

If organic fertilizers are used, they must be certified pathogen-free. Composted sewage sludge should not be used as it may contain pathogens as well as heavy metal contamination.

### Irrigation

Natural surface water (e.g., canal, lake, pond) provides enough organic matter to support the growth of bacterial pathogens. Surface water may be used but tested for the presence of the bacterium *E. coli*, which is an indicator of fecal contamination. Groundwater is less likely to harbor human pathogens and is the safest, most economic source of irrigation water.

Growers must be able to document answers to the following questions: Are irrigation practices safe? What is the water source? How is water stored? Are animals being raised nearby? What tests are performed to ensure the purity and safety of the water?

### Pesticide Usage

Inspecting, monitoring, and documenting proper use of pesticides will prevent unsafe or illegal pesticide residues from contaminating the raw product. Growers must be able to answer the following questions: Do you oversee your pesticide-spraying program? Do you have record-keeping procedures to track all spraying of this crop? Do you or the state/federal governments regularly test your crops for residue levels?

### Harvesting

Hand harvesting may lead to pathogen contamination if field workers practice poor personal hygiene. Workers should wear disposable rubber gloves and replace them during the day as needed.

Field crews must be trained and monitored for personal hygiene. Portable bathroom and hand-washing facilities must be provided in the field. Most importantly, bathrooms should be strapped to a flatbed trailer so they can be moved to distant field locations. Close proximity will more likely encourage their use. An adequate supply of toilet paper, antibacterial soap, running water, paper towels, and a lidded garbage pail is mandatory.

### Field Containers (boxes, buckets, bins, etc.)

Containers (5-gallon buckets) should be non-toxic, easy to clean, and free of extraneous materials (chemicals, nails, wood splinters) that can carry over to the packinghouse. Clean and sanitize these using a Clorox-type agent at the end of each production day. If onions must be field cured, use synthetic bags, preferably those that have been cleaned and sanitized in a strong bleach solution or are new.

### Post-Harvest Handling Activities

Rough handling of onions during unloading, drying, grading, sizing, and packing will lead to surface cuts and bruising of tissue beneath the outer scales. This opens an invasion route for both storage-rot pathogens and human pathogens. To minimize pathogen infiltration, make every effort to cushion the path of the onion between dumping and pack-out. Specifically, employ appropriate padding materials based on the greatest damage sites (Table 11, page 48). With the obvious abuse these padding materials would receive over the course of a packing season, close monitoring is necessary to replace them as they wear.

## Sanitary Guidelines for Packinghouse Operations

### Receiving Incoming Product

Harvest crews should remove as much dirt and mud from the onions and/or containers as is possible before the product leaves the field. Workers should avoid slamming or dropping bags.

### Packinghouse Equipment

Aside from sweeping up scales, onion culls, etc., off the floor, most 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 human pathogens. Cleaning, using a high-pressure detergent solution, at least once a week is recommended in the *Good Agricultural Practices* document published by the USDA/FDA. Spot-spray belt conveyors and other equipment with 5-gallon hand pumps containing a Clorox sanitizer.

### Employee Hygiene

Good employee hygiene is very important. Employee training, health screening, and constant monitoring of packinghouse sanitation practices (hand washing, personal hygiene) are important in reducing contamination cause by employees.

Collect gloves, knives, and any other hand tools at the end of the production day; clean and sanitize them to prevent carry-over cross-contamination.

## Pest Control

A pest-control program should be in place to reduce the risk of contamination by rodents or other animals. In an open or exposed packinghouse operation, the best control is constant vigilance and elimination of any discovered animals and their potential nesting locations. Product and/or product remnants will attract pests; so daily cleaning of the packinghouse to eliminate the attractive food source should help in reducing pest activity.

## Facility Sanitation

Packinghouse facilities have the potential for developing microbial growth on walls, tunnels, ceilings, floors, doors, and drains. Scheduled wash-down and/or sanitizing of the facility will reduce the potential for microbial growth. The cooling system should be monitored and cleaned as necessary, depending on the type of system.

**Table 10. Safety issues to consider in onion production.**

| Production Factor | Potential Hazard | Prevention | Documentation |
|---|---|---|---|
| Land Use | a. Fecal contamination (source of pathogens) from animals | No grazing animals or feedlots on or near production land. | Grower certification of no recent animal husbandry on land used. |
| | b. Toxic pesticide residues in soil | Review pesticide history for plant back restrictions | Pesticide selection/ application records |
| Fertilizers | Pathogenic bacteria from organic fertilizers | Use waiting period of 120 days from application to harvest with fresh manure or use inorganic fertilizer | Certified test results |
| Irrigation Water | a. Pathogenic bacteria from surface water | Test or monitor water supply | Water test results |
| | b. Heavy metal or pesticide residues in groundwater | Test or monitor water supply | Water test results |
| Pesticide Use | Illegal or hazardous residues on product | Employ only professional/licensed applicators and monitor pesticide use | Examine applicator records; test for residues |
| Hand Harvesting | Fecal contamination of product | Field worker personal hygiene; field washing/sanitizing facilities available | Training programs on worker hygiene |
| Field Containers | Soil and human pathogens | Use plastic bins; clean and sanitize all containers | Field sanitation records |

**Table 11. Sources of bruising in onions.**

| Bruise Point | Drop Height | Contact Surface | Padding Type |
|---|---|---|---|
| Unloading conveyor | 6" - 12" | Wood | 3" padded carpet |
| Loading Drying Bin | 1' - 4' | Onion/Wood | Canvas slide chute |
| Wire Transfer Belt | 1" - 12" | Metal Chute | 0.5" PVC foam |
| Incline to Scale Brusher | 4" - 12" | Metal Plate | 0.5" PVC foam |
| Incline to Pregrader | 4" - 12" | Metal Plate | 0.5" PVC foam |
| Incline to Sizing Rings | 4" - 12" | Hard Rubber Belt | 0.5" PVC foam |
| Incline Chute to Labeler | 6" - 10" | Metal Plate | 0.5" PVC foam |
| Labeler to Mesh Bag | 1' - 4' | Concrete Floor | 4" - 6" mattress |

# Production Costs of Onion

*Esendugue Greg Fonsah – Extension Agricultural Economist*

Enterprise budgets are used to estimate production costs and break-even analyses (Tables 12 and 13). 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 particular situation. Table 12, page 50, shows the various break-even cost/price per box of onion. To be profitable, a grower needs a minimum yield of 308 (40 lbs.) boxes per acre and a minimum price of $8.61 per box.

## Type of Costs

Crop production costs include both variable and fixed costs. The variable or operating costs vary with the amount of crop produced. Common variable costs include plant, fertilizer, chemicals, fuel, and labor. In this study, the preharvest variable cost was $1,542 per acre. The inputs that contributed heavily to the preharvest variable costs were plants, fungicides, set plants, and irrigation. The cost of onion plants was $350, equivalent to 23 percent. Fungicide application contributed 16 percent while irrigation was 12 percent of the preharvest variable cost respectively (Table13, page 51).

Total harvesting and marketing costs were $2,409 which comprised input costs such as burlap bags, hand harvesting cost, grading, labeled mesh bags, drying operation, boxes, general labor, and Vidalia Onion Committee Assessment fees respectively. The biggest cost components were: hand harvest labor - $556; grading - $484; boxes - $676; general labor - $381. Adding the preharvest, harvesting, and marketing cost equals total variable cost of $3,951 (Table 14, page 52).

Fixed costs include items such as equipment ownership (depreciation, interest, insurance, and taxes), management, and general overhead costs. Most of these costs 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 variable or a fixed cost. 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 doubled-cropped, charge each enterprise half the annual rate. Ownership costs for tractor and equipment (depreciation, interest, taxes, insurance, and shelter) are included as a fixed cost per hour of use. The daily use of irrigation is considered as variable cost while irrigation material and installation are classified as fixed cost (Table 12 and 13) expenses. Overhead and management cost was $231.30 and was calculated by taking 15 percent of all preharvest variable 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 onion is $4,305.28, which is the sum of total variable cost plus total fixed cost respectively. The preharvest variable costs and the fixed costs decline fairly rapidly with increases in yields.

## Budget Uses

In addition to estimating the total costs and break-even 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 to exceed 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 14) shows an 85 percent chance of covering all costs. One-half the time, the budgeted grower would expect to return of $2,751 or more. Half the time, he would expect a return of $2,695. One year out of six he would expect to make more than $4,101 per acre and one year out of six to lose more than $1,447. Readers should recognize 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 local County Extension Office for a copy or visit http://www.ces.uga.edu/Agriculture/agecon/printedbudgets.htm.

**Table 12: Break-Even (B/E) Cost Analysis Per (40 lbs.) Box of Onion**

| | |
|---|---|
| Break-even preharvest variable cost per (40 lbs.) box ($) | 3.08 |
| Break-even harvesting and marketing cost per (40 lbs.) box ($) | 4.82 |
| Break-even fixed costs per (40 lbs.) ($) | 0.71 |
| Break-even total budgeted cost per (40 lbs.) box ($) | 8.61 |
| Break-even yield per acre (40 lbs. boxes) | 308 |

**Table 13. Estimated cost of producing onion in Georgia, 2008**

| | Best | Optimist | Median | Pessimist | Worst |
|---|---|---|---|---|---|
| Yield (40-pound boxes) | 1,000 | 750 | 500 | 250 | 100 |
| Price per box | $20.00 | $17.00 | $14.00 | $11.00 | $8.00 |

| Item | Unit | Quantity | Price | Amt/acre |
|---|---|---|---|---|
| **Variable Costs** | | | | |
| PreHarvest Costs | | | | |
| Plants | Thou | 70 | $5.00 | $350.00 |
| Lime, applied | Ton | 1 | $29.00 | $29.00 |
| Fertilizer | Cwt | 15 | $11.00 | $165.00 |
| Side dressing | Cwt | 4 | $13.00 | $52.00 |
| Insecticide | Acre | 1 | $54.00 | $54.00 |
| Fungicide | Acre | 1 | $249.00 | $249.00 |
| Herbicide | Acre | 1 | $30.00 | $30.00 |
| Machinery (Includes op lbr) | Acre | 1 | $21.61 | $21.61 |
| Set Plants | Acre | 1 | $333.00 | $333.00 |
| Land rent | Acre | 1 | $0.00 | $0.00 |
| Irrigation | Appl. | 8 | $24.00 | $192.00 |
| Interest on Oper. Cap. | $ | 1,475.60 | $0.10 | $66.40 |
| **Total PreHarvest** | | | | $1,542.01 |
| Harvest and Marketing Costs | | | | |
| Hand harvest labor | Bag | 400 | $1.39 | $556.00 |
| General labor | Hr. | 50.00 | $7.62 | $381.00 |
| Burlap bags (prorated) | Ea. | 400 | $0.36 | $144.00 |
| Grading | Bag | 400 | $1.21 | $484.00 |
| Labeled mesh bags | Ea. | 100 | $0.48 | $48.00 |
| Boxes | Ea. | 400 | $1.69 | $676.00 |
| Drying | Bag | 400 | $0.18 | $72.00 |
| Vidalia Onion Committee Assessment | Bag | 400 | $0.12 | $48.00 |
| **Total Harvest and Marketing** | | | | $2,409.00 |
| **Total Variable Costs** | | | | $3,951.01 |
| Fixed Costs | | | | |
| Machinery | Acre | 1 | $44.20 | $44.20 |
| Irrigation | Acre | 1 | $78.78 | $78.78 |
| Land | Acre | 1 | $0.00 | $0.00 |
| Overhead and Management | $ | 1,542.00 | $0.15 | $231.30 |
| **Total Fixed Costs** | | | | $354.28 |
| **TOTAL BUDGETED COST PER ACRE** | | | | $4,305.29 |

**Table 14. Risk Rated Returns Over Total Costs of Producing Onion in Georgia, 2008**

| | Optimistic | | | Expected | Pessimistic | | |
|---|---|---|---|---|---|---|---|
| Returns($) | 6,803 | 5,452 | 4,101 | 2,751 | 1,447 | 144 | -1,159 |
| Chances | 7% | 16% | 31% | 50% | | | |
| Chances | | | | 50% | 31% | 16% | 7% |

Net return levels (TOP ROW);

The chances of obtaining this level or more (MIDDLE ROW); and

The chances of obtaining this level or less (BOTTOM ROW).

| | | | |
|---|---|---|---|
| **Chances for Profit** | **85%** | **Base Budgeted Net Revenue** | **$2,695.00** |

# Marketing Onions

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Per capita consumption of onions has risen from 12.2 pounds per person in 1983 to 20.4 pounds per person in 2007 based on a farm weight basis (ERS/USDA). The highest per capita consumption was in 2004 when 21.6 pounds were reported. About one-third of this is due to sweet onion consumption, with the Vidalia onion a significant, successful part. Onions along with other alliums have been touted in recent years for several health benefits, which have also contributed to increased consumption. While per capita consumption of onion continues to increase, the per capita consumption of dehydrated onion is fluctuating. In 1982, the per capita consumption of dehydrated onion stood at 2.0 pounds per person, and in 2007 that figure decreased to 1.5 pounds per person. In 1999, the highest consumption was recorded at a record high of 2.3 pounds per person. Total onion production in the United States has decreased slightly from 2004-2006 (Table 15, page 54). Harvested acres of spring non-storage onions have decreased 3 percent during this period. Georgia production of harvested acres is down from 14,500 acres in 2004 to 10,500 in 2006.

Prices for onions have remained strong in Georgia. Prices in Georgia are two times higher than prices for spring non-storage onions in Arizona or California (Table 16, page 54). Furthermore, prices in Georgia are two to three times higher than the national seasonal average price. For instance, in 2000 the national seasonal average price was $11.20 per cwt whereas Georgia growers enjoyed a higher price of $26 per cwt, almost 2.3 times higher. In 2003, the national seasonal average price was $13.7 per cwt whereas Georgians received $34.3 per cwt, i.e. 2.5 times higher. Although production has not been consistent, 3.2 million cwt were produced in 2000 with as low as 1.4 million cwt in 2002. This drastic decrease can be blamed on several factors including weather, pests, and diseases. In 2004, Georgia had a record high production of 3.8 million cwt. This put a downward pressure on prices as growers only received $23.5 per cwt.

China is the leading producer of onion in the world followed by India; the United States is ranked third. Other important producing countries are Pakistan and Turkey. Total onion production in the United States was 72 million cwt in 2000. Production in the United States has been more or less consistent. The total U.S. production in 2005 was 74 million cwt, representing 5.9 percent of the total world production for the same time period. On the other hand, production for number one ranked China is consistently increasing from 311 million cwt in 2000 to 420 million cwt in 2005, or an equivalent of 33.3 percent to the total world production. India has been steadily increasing its production also from 104 million cwt in 2000 to 121 million cwt in 2005, 9.6 percent of total world production (Table 17, page 55).

In terms of acreage, the leading countries are China, India, Pakistan, Russian Federation, Indonesia, and the United States. Number one ranked China has been increasing its acreage steadily from nearly 1.7 million acres in 2000 to over 2.2 million acres in 2005, equivalent to a 35.3 percent increase. Furthermore, in 2005, China cultivated 28.5 percent of total world acreage while the United States' total harvested acreage only represented 2.1 percent of the world total (Table 18, page 55).

The United States fresh onion imports have been increasing rapidly. From 2000 to 2007, imports have increased from 483.3 million pounds to 850 million pounds, equivalent to a 75.9 percent increase. On the other hand, exports have been declining from 768.1 million pounds in 2000 to 625 million pounds in 2007, equivalent to a 18.6 percent decrease (ERS/USDA). However, there was no significant difference in the quantities imported and exported from 2001-2006 (Figure 24, page 55).

**Table 15. Harvested Acres, 2004-2006.**

| | Acres Planted | | | Acres Harvested | | |
|---|---|---|---|---|---|---|
| | 2004 | 2005 | 2006 | 2004 | 2005 | 2006 |
| **Spring Non-Storage** | | | | | | |
| Arizona | 1,600 | 2,000 | 1,000 | 1,600 | 2,000 | 1,000 |
| California | 7,300 | 8,200 | 8,100 | 7,100 | 8,000 | 7,900 |
| Georgia | 16,500 | 13,500 | 14,000 | 14,500 | 10,500 | 10,500 |
| Texas | 14,500 | 17,000 | 17,700 | 12,500 | 15,500 | 15,200 |
| TOTAL | 39,900 | 40,700 | 40,800 | 35,700 | 36,000 | 34,600 |
| **Summer Non-Storage** | | | | | | |
| California | 8,800 | 9,700 | 9,800 | 8,400 | 9,300 | 9,400 |
| Nevada | 3,400 | 2,400 | 2,600 | 3,400 | 2,400 | 2,600 |
| New Mexico | 7,300 | 6,500 | 6,000 | 7,100 | 6,400 | 5,500 |
| Texas | 2,900 | 1,000 | 1,000 | 2,800 | 900 | 900 |
| Washington | 1,500 | 1,400 | 1,500 | 1,500 | 1,400 | 1,500 |
| TOTAL | 23,900 | 21,000 | 20,900 | 23,200 | 20,400 | 19,900 |
| **Storage and/or Processing Onions** | 115,600 | 111,320 | 113,580 | 110,250 | 108,820 | 108,480 |
| TOTAL ONIONS | 179,400 | 173,020 | 175,280 | 169,150 | 165,220 | 162,980 |

Source: USDA Vegetables 2006 Summary, January 2007.

**Table 16. Value by season, state, and U.S., 2004-2006**

| | Dollars/cwt | | | Total ($1,000s) | | |
|---|---|---|---|---|---|---|
| | 2004 | 2005 | 2006 | 2004 | 2005 | 2006 |
| **Spring Non-Storage** | | | | | | |
| Arizona | 8.80 | 10.20 | 9.00 | 7,040 | 9,384 | 4,410 |
| California | 10.10 | 12.40 | 9.30 | 36,219 | 47,120 | 30,495 |
| Georgia | 23.50 | 29.70 | 25.20 | 88,595 | 65,489 | 82,026 |
| Texas | 22.60 | 29.70 | 20.00 | 87,575 | 138,105 | 82,080 |
| TOTAL | 18.20 | 22.50 | 17.90 | 219,429 | 260,098 | 199,011 |
| **Summer Non-Storage** | | | | | | |
| California | 8.80 | 11.00 | 12.40 | 41,395 | 56,265 | 65,274 |
| Nevada | 16.00 | 15.00 | 18.00 | 34,816 | 31,680 | 33,696 |
| New Mexico | 12.60 | 15.80 | 17.40 | 46,078 | 53,594 | 45,936 |
| Texas | 24.10 | 33.70 | 34.00 | 24,968 | 11,222 | 7,344 |
| Washington | 16.00 | 23.60 | 22.40 | 8,400 | 12,225 | 12,768 |
| TOTAL | 12.90 | 14.40 | 15.60 | 155,657 | 164,986 | 165,018 |
| **Storage and/or Processing Onions** | 5.93 | 9.34 | 11.30 | 296,540 | 423,714 | 503,715 |
| TOTAL ONIONS | 9.06 | 12.40 | 13.10 | 671,626 | 848,798 | 867,744 |

Source: USDA Vegetables 2006 Summary, January 2007.

**Table 17: Dry Onion Production in Leading Countries and the World, 2000-2005 (million cwt).**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| China | 311 | 331 | 365 | 387 | 398 | 420 |
| India | 104 | 116 | 120 | 121 | 121 | 121 |
| U.S.A. | 72 | 68 | 70 | 73 | 83 | 74 |
| Turkey | 49 | 47 | 45 | 39 | 45 | 44 |
| Pakistan | 36 | 35 | 31 | 32 | 32 | 39 |
| Others | 505 | 515 | 522 | 525 | 573 | 562 |
| World | 1,077 | 1,111 | 1,153 | 1,177 | 1,252 | 1,260 |

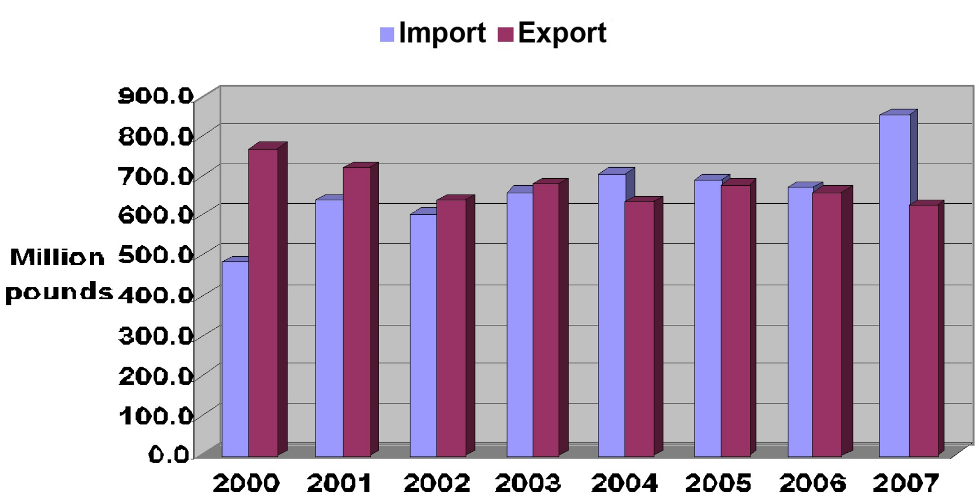
Source: Vegetables and Melons Situation and Outlook Yearbook /VGS-2007/July 26, 2007 pg. 176.

**Table 18: Dry Onion harvested acreage in leading countries, 2000-2005 (1,000 acres)**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| China | 1645 | 1781 | 1904 | 1978 | 2102 | 2226 |
| India | 1112 | 1236 | 1310 | 1310 | 1310 | 1310 |
| Pakistan | 271 | 261 | 256 | 267 | 269 | 316 |
| Russian Federation | 273 | 274 | 278 | 292 | 314 | 309 |
| Indonesia | 208 | 203 | 197 | 218 | 219 | 211 |
| U.S.A. | 166 | 162 | 163 | 166 | 169 | 162 |
| Others | 3198 | 3169 | 3146 | 3192 | 3231 | 3276 |
| World | 6872 | 7084 | 7254 | 7422 | 7614 | 7809 |

Source: Vegetables and Melons Situation and Outlook Yearbook/VGS-2007/July 26, 2007, pg. 179.

**Figure 24: U.S. Fresh Onion Import and Export, 2000-2007**




Source: Vegetables and Melons Situation and Outlook Yearbook/VGS-2006/July 27, pg. 73, Economic Research Service, USDA.

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