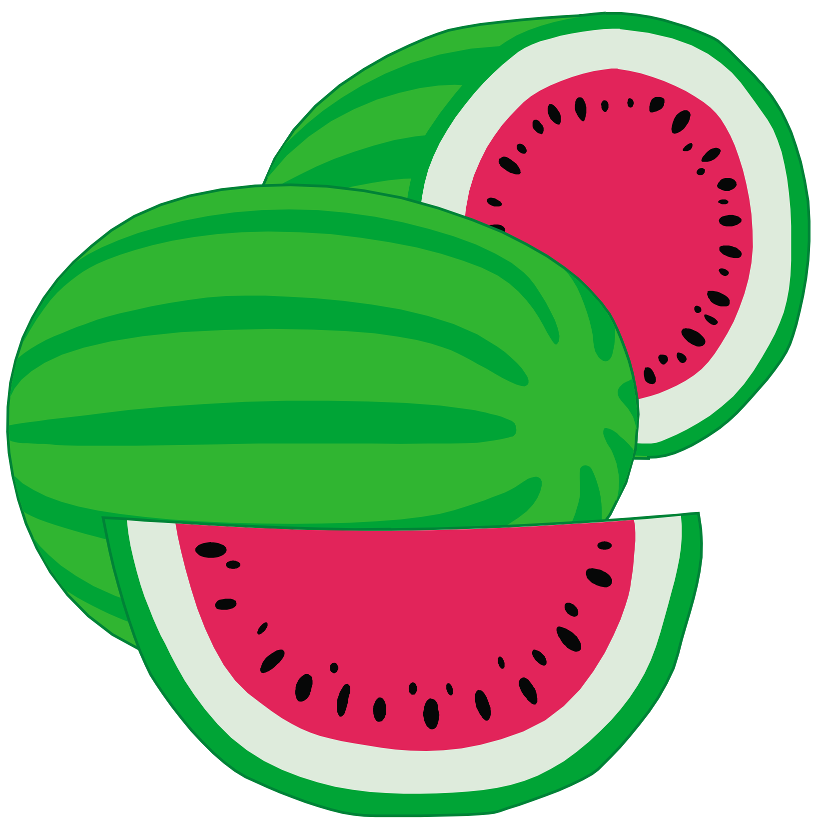
Commercial

Watermelon

Production



Foreword

Ten years have passed since this publication was updated; many changes have occurred in the watermelon industry during that time. The 13 chapters in this publication represent the latest information available on successful watermelon production. This publication is the compilation of information through the Georgia Vegetable Team, a cross-discipline commodity group within the University of Georgia. Thanks are extended to all the contributors and reviewers for their efforts in putting this publication together.

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Culture

George E. Boyhan, Darbie M. Granberry and W. Terry Kelley, Extension Horticulturists

Watermelon is a warm-season crop related to cantaloupe, squash, cucumber and pumpkin. Watermelons can be grown on any well-drained soil throughout Georgia but are particularly well adapted to the Coastal Plain soils of South Georgia. Yields of 20,000 to 40,000 pounds per acre are common. More than 35,000 acres of watermelon are produced in Georgia, with more than 25 percent of this produced on plastic mulch.

Watermelons will continue to be an important part of vegetable production in the state. Increases in average yield per acre will continue as more growers adopt plastic mulch, intensive management and new hybrid varieties.

Cultivars

Watermelons range in shape from round to oblong. Rind colors can be light to dark green with or without stripes. Flesh colors can be dark red, red or yellow.

Watermelon varieties fall into three broad classes based on how the seed were developed: open-pollinated, F_1 hybrid, and triploid or seedless.

Open-pollinated varieties are developed through several generations of selection. The selection can be based upon yield, quality characteristics and disease resistance. Open-pollinated varieties have true-to-type seed (seed saved from one generation to the next will maintain the same characteristics) and are less expensive then F1 hybrid varieties.

F_1 hybrids are developed from two inbred lines that have been selfed for several generations and then crossed, with the subsequent seed sold to growers. F_1 hybrid seed will exhibit increased uniformity of type and time of harvest compared with open-pollinated seed and can exhibit as much as a 20 percent to 40 percent increase in yields over open-pollinated varieties grown under similar conditions. The disadvantages of F1 hybrid seed are cost and availability. F_1 hybrid seed will be as much as five to 10 times as costly as open-pollinated seed, and available F_1 hybrid varieties will change from year to year.

The third type is triploid or seedless watermelon. These are developed by creating watermelon plants with double the usual chromosome number and crossing them with normal watermelon plants. The resulting plants have one-and-a-half times the normal chromosome number. Because they have an odd number of chromosomes, they cannot form viable seed. In addition, they produce very little pollen; therefore, normal watermelon must be planted with triploid watermelon as a source of pollen. Although triploid watermelons are referred to as seedless, they are not truly seedless but rather have undeveloped seeds that are soft and edible. Triploid seeds will be even more expensive than F_1 hybrid seeds, and the melons should command a premium in the marketplace (see *Growing Seedless Watermelons*).

Watermelons are also grouped according to fruit shape, rind color or pattern, and size. These groups are often named for a popular variety with those characteristics. For example, oblong melons with dark stripes on a light background in the 25 to 35 pound range are called Jubilee types after the popular Jubilee variety. Melons of similar shape and size as Jubilee but with a light green rind are called Charleston Gray types, again for a popular cultivar, Charleston Gray. Round melons in the range of 20 to 30 pounds with a striped rind are called Crimson Sweet types. Small oblong melons (15 to 25 pounds) with a dark green rind and light yellow stripe with dark red flesh are called Allsweet types. Watermelons with a blocky shape (between a Jubilee and Crimson Sweet type) are referred to as Royal Sweet or Mirage types. Finally, round watermelons of 10 pounds or less are referred to as icebox types to denote their ability to fit into a refrigerator.

Because varieties are constantly being changed and market trends are also changing, selecting varieties acceptable for your market is important. Consult your seed dealer, buyers, brokers or your county Extension office for the latest information on available varieties.

Planting and Spacing

Watermelon seed germinates at soil temperatures of 68° to 95° F; however, germination below 70° is very slow. At a soil temperature of 77°, watermelon plants should emerge in about five days.

Watermelon seed should not be planted until soil temperatures are warm enough to ensure rapid germination. Planting seed too early will delay germination, can result in uneven stands and will increase the likelihood of crop loss. Early seeding can, however, result in an early harvest, which generally commands better prices. These contradictory elements in deciding when to plant watermelon seed are best resolved by successive plantings that attempt to produce for the early market while ensuring a crop by planting when soils are warmer.

Seed should be planted approximately 1 inch deep. The amount of seed required (usually 1 to 2 pounds per acre) depends upon seed size, germination and plant spacing. Correctly labeled, uniform, disease free, certified seed with 85 percent to 90 percent germination is preferred.

There are several methods of planting watermelon. With the widespread use of more expensive hybrid seed, equipment that can plant to stand or come close to this is best. Precision seeding equipment, plug mix planting and transplants reduce or eliminate the need to thin stands after planting.

Plug mix planting consists of blending watermelon seeds, fertilizer and water with a growing medium of approximately one-third vermiculite and two-thirds peat. Prepared in cement mixers, the mix often is allowed to remain in bags for 24 to 48 hours prior to planting to allow seed to imbibe water and begin the germination process. Precision plug mix planters dispense the mix in the field by injecting 1/8 to ½ cup of mixture (plug) per hill. The mix should have enough seed to dispense from three to five seeds per hill. Plug mix planting is especially advantageous when planting watermelon seeds in plastic mulch: These planters punch or burn holes in the plastic to insert the mix. Growers who have little or no experience with plug mix planting should contact a county Extension office for additional information before using this specialized procedure.

Watermelons traditionally have been spaced 6 to 8 feet between hills on bare ground without irrigation. With irrigation, use a spacing of 5 to 6 feet between hills. With plastic mulch and trickle irrigation, use an in-row spacing of 3 feet and between-row spacing of 6 to 8 feet. Icebox watermelons can be spaced even more closely, with in-row spacings of 2 feet and between-row spacings of 5 feet.

Pollination

Watermelons produce two types of flowers. Most varieties generally produce imperfect female and male flowers (Figure 1). When flowering begins in watermelon, male flowers will be produced at every node while female flowers will be produced approximately every seventh node.

Watermelon flowers are viable for only one day; therefore, an adequate population of pollinating insects must be available every day during the flowering period. Even with sufficient pollinators, it is not uncommon for watermelons to abort flowers. Under average conditions, two to three fruit should set per plant. The actual number of fruit set will depend on variety, cultural practices, environmental conditions, irrigation and number of pollinating insects.

Figure 1. *Watermelon flowers: female (left) and male.*

Watermelons require insects for proper pollination and fruit growth. Research has shown that each female flower must be visited, on average, seven times by a pollinating insect to ensure proper fruit set. Insufficient pollination results in misshapen melons, which must be culled (Figure 2).

Figure 2. *Immature watermelon. Poor shape is due to insufficient pollination.*

Individually, honeybees are not as efficient at pollinating as wild bees, but their large numbers make them very good at ensuring proper pollination. If an insufficient number of pollinators are present, supplement them with domestic hives. One strong hive (30,000 bees in a two-story hive) for every 1 to 2 acres is recommended. Ideally, hives should be spaced evenly throughout the field. This, however, may be impractical due to inaccessibility to the field. Hives should have adequate clean water. Hives often are clustered along the edge of the field, which results in bees foraging further into a field because of competition between the hives. Apply pesticides when bee activity is low to minimize impact on the hives. This will occur late in the day, around dusk and on overcast days. Check pesticide labels for additional precautions concerning bees.

Watermelon flowers are not nutritionally attractive to honeybees; therefore, blooming weeds or other crops can outcompete watermelons in attracting honeybees. Destroy nearby flowering plants that may be attractive to honeybees. This will ensure that the bees work the watermelon flowers exclusively.

Monitor hives and honeybee activity during flowering. Early to mid-morning is the best time to monitor bee activity. If numerous bees are not vigorously working watermelon flowers, corrective action must be taken immediately to prevent poor or delayed set.

Soils and Fertilizer Management

George E. Boyhan, Darbie M. Granberry and W. Terry Kelley, Extension Horticulturists

Most well-drained soil, whether clayey or sandy can be managed to produce a good crop of watermelon. The best soils, however, are sandy loams that have not been in cucurbit (cantaloupe, cucumber, squash, etc.) production for a minimum of five years.

Soils with a history of watermelon diseases should be avoided or fumigated to avoid problems (please see the chapter on diseases and consult the current edition of the Georgia Pest Control Handbook). Your local county Extension agent can help with determining potential disease problems.

Land preparation involves one or more tillage operations performed (1) to make the soil more suitable for seeding and seedling (or transplant) establishment, (2) to enhance productivity by providing the best soil structure for subsequent root growth and development, and (3) to help control some disease problems.

Several operations may be required to prepare land for planting. This is partially determined by previous cropping history. Land that has been under cultivation for several years may develop a hardpan several inches below the surface. This is particularly problematic on clay soils. To penetrate and break up this hardpan, a subsoiler should be used.

Litter from previous crops should be disked and deep turned with a moldboard plow two to four weeks prior to planting to insure its decomposition. Broadcast fertilizer should be applied at this time (if no other soil preparation is anticipated) or just before final bedding.

Watermelons respond favorably to warm soils. Raised beds tend to warm quickly and are particularly desirable for early season production. Raised beds will facilitate drainage in heavy soils but are more prone to drying; therefore, particular care should be taken with watering, especially during the first two weeks after emergence.

Root growth can be severely restricted by compacted soil. Proper land preparation should eliminate or significantly reduce soil compaction. Recent studies have determined that watermelon root growth is primarily confined to noncompacted soil. Disking fields after they have been plowed tends to recompact the soil and should be avoided. Tillage systems utilizing the moldboard plow without subsequent recompacting operations consistently produce the highest watermelon yields. Basically, this superior performance results from more extensive root systems that are more efficient at extracting nutrients and water from the soil.

Cover Crops and Green Manure

Winter cover crops help protect the soil from excessive water and wind erosion. When incorporated into the soil as green manure, cover crops add organic matter (OM) to Coastal Plain soils, which are naturally low (often less than 1 percent) in OM.

Soil organic matter consists of plant and animal residues in various stages of decay. Adding OM improves soil structure, which, in turn, enhances soil tilth (helps to reduce compaction and crusting), increases water infiltration and decreases both water and wind erosion. Also of importance, OM serves as a storehouse of many plant nutrients. Furthermore, OM improves the efficiency of applied fertilizers by increasing the soil's ability to retain plant nutrients under leaching conditions. Georgia watermelon growers frequently plant wheat, oats, rye or ryegrass as winter cover crops. Whenever these non-nitrogen-fixing cover crops are to be incorporated as green manure, they should be provided with adequate nutrients (especially nitrogen) during their growth. This increases the quantity of OM produced and helps provide a carbon to nitrogen (C:N) ratio less likely to tie-up (immobilize) nitrogen during decomposition. As a general rule, when nonleguminous OM having a C:N ratio greater than 30 to one is incorporated into the soil, it is usually beneficial to broadcast supplemental nitrogen before incorporation. The amount of nitrogen to add varies, depending on the C:N ratio, soil type and amount of any residual nitrogen in the soil. Typically, green manure crops should be plowed under as deeply as possible with a moldboard plow so that large amounts of crop residue will not be in the immediate vicinity of germinating watermelon seed. Lush cover crops should be turned under at least two weeks prior to planting the succeeding crop.

If small grains are grown as a cover crop, strips of grain (2 feet to 6 feet wide) left in spray or harvest lanes provide windbreaks that help reduce damage and sandblasting of small plants during early spring. To minimize the possibility of insect migration to the watermelon crop, grain strips should be turned under before the onset of senescence.

Lime and Fertilizer Management

The only way to accurately manage soil fertility and pH is to have the soil tested. Soil sampling must be conducted in such a manner that it is representative of the field being sampled. This is essential to ensure accurate results and recommendations. Your county Extension agent can help you with the proper method for collecting a soil sample. The University of Georgia Soil and Plant Analysis Laboratory can analyze your soil and make recommendations.

A good fertilizer management program for watermelon production answers four basic questions:

1. What fertilizer materials (including lime) are to be applied?
2. In what quantities will they be applied?
3. How frequently will they be applied?
4. By which method(s) (broadcasted, banded, etc.) will they be applied?

In addition, the most successful management programs include frequent evaluations and modifications, if needed, to deal with unanticipated problems such as floods, droughts and other factors that affect the plants' ability to utilize nutrients.

Soil pH measures the acidity or alkalinity of the soil. A pH of 7 is considered neutral, with values above 7 being alkaline and values below 7 acid. Most soils in Georgia are slightly to strongly acid. Soil pH will have a profound effect on plant growth, development and, ultimately, yield. Soil pH affects the availability of nutrients for plant growth. A slightly acid soil with a pH of 6.0 to 6.5 is ideal for watermelons.

The only accurate way to determine the soil pH is to have the soil tested. This analysis can determine if lime is required to raise the pH. Lime is relatively slow acting in raising soil pH and is relatively immobile in soils. For this reason lime should be added two to three months before planting and completely incorporated into the top 6 to 8 inches. Soils that are also deficient in magnesium should receive dolomitic lime instead of calcitic lime.

For watermelon production, the maximum recommended amount of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) is 120 pounds per acre. Watermelons are a relatively long-season crop; therefore, applying fertilizer in small amounts several times throughout the season will maximize production. Rain and overhead irrigation can leach nutrients from the soil, particularly N and K. All required phosphorus can be applied preplant and should remain available throughout the growing season, because it is relatively immobile in the soil.

Many different methods exist for applying the recommended fertilizer. A simple method would be to broadcast and incorporate all of the P and K and apply half the N preplant and half the N four to six weeks after seeding.

More complex application methods generally result in maintaining optimum nutrient levels throughout the growing season. In one such method, a modified broadcast concentrates the fertilizer in the area of the roots compared with broadcasting. With the modified broadcast method, apply the fertilizer in bands 2 to 3 feet wide in the row prior to planting. This method will also eliminate the potential for burning emerging plants if fertilizer were banded near the emerging seedlings. In this method, all the P is applied preplant with any micronutrients. One-third to half the recommended N and K are also applied in this modified broadcast. At approximately three weeks after seedling emergence, apply one-fourth the remaining N and K on the sides of the beds just past vine tips. At approximately six weeks after emergence, apply the remaining N and K.

Apply 1 pound of boron per acre and 10 pounds of sulfur per acre. If the soil test zinc level is low, apply 5 pounds of zinc per acre.

Leaching rains or insufficient applications may result in nitrogen and/or magnesium deficiencies after vines have covered the soil surface. If under center pivot, symptoms may be alleviated by fertigating 20 to 30 pounds of nitrogen per acre or 10 to 15 pounds magnesium per acre. If fertigation is not practical, 10 to 15 pounds of magnesium sulfate in approximately 100 gallons of water can be applied as a foliar spray to correct magnesium deficiency. To alleviate nitrogen deficiencies after full vine cover, sodium nitrate may be broadcast over the top (when vines are dry) at 135 to 175 (22 to 28 pounds N) pounds per acre. Granular calcium nitrate should not be used over the top, because it tends to result in a significant incidence of leaf burn. Any time granular fertilizer is applied over the top, leaf burn may be reduced by thoroughly washing the fertilizer from the leaves with irrigation water.

Watermelon growers have occasionally experienced unsatisfactory fruit set even with sufficient bee activity. Two to three foliar applications of water-soluble boron (approximately 1 ounce by weight of actual boron per application) at weekly intervals coinciding with opening of the first female flowers can enhance pollination and improve fruit set. Many growers routinely use a commercial formulation that also contains calcium (2 to 3 ounces by weight of actual calcium per application) to help prevent blossom-end rot. A good fertilizer management program includes frequent observations of plants for any nutrient deficiency symptoms. Frequent (eight to 12 days) tissue analyses may be used to monitor nutrient levels in plant tissues. These tests provide a sound basis for fertilizer applications prior to plant stress and symptom development. For optimal yield and quality, monitor watermelon fields frequently and apply supplemental applications of fertilizer promptly if needed.

Melon Defects

Blossom-end rot (BER) is a physiological or nonparasitic disorder related to calcium deficiency, moisture stress or both. Prevention recommendations include adequate amounts of calcium, proper soil pH (6 to 6.5), and a uniform and sufficient supply of moisture. The incidence of BER usually is quite variable from season to season and tends to occur more readily in oblong melons. Watermelons having BER are considered unmarketable (Figure 3).

Figure 3. *Blossom-end rot appears as black dead tissue where the blossom was attached.*

Hollow heart (HH) and **white heart** (WH) are two physiological disorders influenced by genetics, environment and, probably, a number of nutritional factors.

To decrease the incidence of these two problems, only cultivars that have not shown unusually high incidences of HH or WH should be planted. In addition, the crop should be grown under optimal (as close as possible) nutritional and moisture conditions. HH and WH harm watermelon quality and may be severe enough to cause potential buyers to reject melons (Figure 4).

Figure 4. *Hollow heart and white heart are generally avoided by planting appropriate varieties.*

Sunscald is damage to the melons caused by intense sunlight. Sunscald can be particularly severe on dark-colored melons. Developing and maintaining adequate canopy cover to afford protection (shade) to the melons may prevent sunscald. Sunscald reduces quality by making melons less attractive and may predispose the melon to rot.

Stem splitting can occur in seedlings grown for transplanting. This problem seems to be associated with high humidity and moisture that can occur under greenhouse conditions. Watering evenly to maintain soil moisture, avoiding wet-dry cycles in the media and good air circulation may help alleviate these problems (Figure 5).

Figure 5. *Stem splitting. Longitudinal splits can occur in greenhouse-grown transplants. Theses transplants are still suitable for planting.*

Sandblasting occurs when wind and blowing sand damage seedlings when first planted. This appears as dead or dying tissue usually on the side of the prevailing winds (Figure 6).

Figure 6. *Sandblasting. White dead tissue on the stem or leaves is usually indicative of this problem.*

Transplant handling damage may result at the soil line because of handling. Tops will flop around and may wilt more readily. In addition, brown or callused tissue may appear at the soil line. Transplants with this damage should be planted slightly deeper to prevent any further damage.

Watermelon Transplant Production

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Transplanting watermelons offers several advantages:

- Plants can be produced under greenhouse conditions when outdoor conditions are not conducive to plant growth.
- Seed-use efficiency increases, which is especially important with costly hybrid and triploid seed.
- Soil crusting and damping off, detrimental to seedling growth, can be eliminated or reduced.
- Planting depth is more uniform.
- It usually results in earlier harvests.
- It is the only cost-effective way to grow seedless watermelons.

The disadvantages of transplanting include:

- higher variable costs,
- increased labor costs,
- holding plants if weather delays planting,
- fragile watermelon seedlings easily broken during transplanting,
- higher cost than direct-seeded watermelons if newly transplanted seedlings are killed by frost, and
- possible increased incidence of diseases such as fruit blotch.

Purchased transplants should be inspected carefully.

Figure 7. *Transplant production. These Georgia Department of Agriculture inspected watermelon transplants are being produced in a greenhouse.*

Yellowed or flowering transplants should not be accepted because they may be too old to grow properly. Transplants of standard varieties more than seven weeks old may never perform well in the field. Purchased watermelon transplants should be pathogen and insect free (Figure 7). If plants must be held for several days due to bad weather, they may elongate, making transplanting difficult.

Growers who raise their own transplants can control growing conditions to produce suitable plants and to reduce the risk of importing diseases that can be a problem with purchased transplants. Successful transplant production depends on four basic requirements:

- a weed-, insect- and disease-free medium;
- adequate heat and moisture;
- high-intensity light of good quality for stocky plant growth (avoid yellowed fiberglass structures); and
- a hardening-off period when plants are subjected to lower temperatures and/or less water prior to transplanting to the field.

The time for watermelon transplanting will depend on frost-free dates, but plants generally will take three to five weeks to be field ready (Table 1) depending on variety and growing conditions. Plants grown under less than ideal conditions will take longer to produce.

Containers

Watermelons suffer transplant shock if the roots are even minimally disturbed. Watermelons must therefore be sown directly in the container that will transfer them to the field. Generally, the size of the transplant container is more important than the type of container. Research has shown that 1-, 1½-, and 2-inch containers, if properly scheduled, can be used successfully without reducing plant vigor or production. The cost of the container may determine the choice of size. Larger containers (1½ inch) are better designed to allow continued root growth and avoid the development of root-bound transplants if the weather prevents timely planting. Root-bound transplants may never grow properly.

Media

Transplants should be grown in a commercially prepared media suitable for vegetable plants. Many commercial mixes (Fafard Mixes, Jiffy Mix, Metro-Mix, Pro-Mix, Redi-earth, Terra-Lite, etc.) are readily available. Commercial mixes are preferred due to consistency of performance.

Sowing

Sow one to two seeds per container for open-pollinated varieties and one seed per container for hybrids to reduce seed costs. Pinch off or cut seedlings to avoid disturbing the roots. Do not pull seedlings out of the container to thin.

Growing Conditions

Cultural conditions under which watermelons grow best are described in Table 1. High temperatures and low light will produce spindly plants. Conversely, low temperatures will delay plant development. Low temperatures can be used when trying to slow plant growth as field planting approaches.

Watering

Uniformly moist media will ensure good germination, but overly wet media will encourage damping off and high seedling mortality. Established transplants should be watered only when necessary. Excessive watering leads to succulent plants with restricted root growth. Water should be applied only when the surface of the media is dry to the touch. As plants grow larger, their water needs will increase. They may need water daily when approaching transplant size. The media should be moistened thoroughly until water drips through the container's drain holes. Water in the morning, when possible, to allow the foliage to dry before night. Wet foliage encourages disease.

Fertilizer

The amount, concentration and frequency of fertilizer applied can control transplant growth. Different formulations of media contain varying amounts of fertilizer. Some media have none, some have a small amount just to stimulate early growth of transplants, and other media contain all the fertilizer needed to produce field-ready transplants. Many transplant growers prefer using media that doesn't contain fertilizer. They feel they can manage transplant growth better using soluble fertilizer (fertigation), because it allows them to directly control the availability of nutrients (amount and time of application). If you use media that contains fertilizer, monitor transplant growth and appearance closely so that you can make timely applications of soluble fertilizer should additional fertilizer be needed.

Many soluble fertilizers are available for application through the irrigation water. This allows adjustments in fertilizer application according to plant needs, stage of development and environmental conditions. Fertilizer rates generally are specified on the product label. It is very easy to over-fertilize a small area. Frequency of fertilization (daily or weekly) depends on the program schedule. More frequent applications of smaller amounts of fertilizer are preferable and tend to produce more even and uniform growth.

Hardening-off

Watermelons need not undergo a long hardening-off period; three to four days are sufficient. Hardening-off can be initiated by reducing greenhouse temperature and by withholding water or limiting fertilizer. Hardened plants are more able to withstand chilling stress, mild water stress, drying winds or high temperatures. Hardened plants generally produce new roots more rapidly than unhardened plants. Overly hardened plants grow slowly and in severe cases never fully recover.

Figure 8. *Transplanting watermelons*

Planting

A watermelon transplant should be set slightly deeper than grown in the greenhouse (Figure 8). This helps prevents damage at the root/stem interface that can occur due to blowing winds. Peat pots should not have any portion remaining above ground because the pot itself will act as a wick to draw moisture from the soil, often desiccating the roots or frequently causing moisture stress. Finally, transplants should be watered as soon as possible after transplanting to remove air pockets surrounding the roots and to ensure sufficient soil moisture for good root establishment. Many transplanting rigs are capable of delivering water to each transplant as it is set. Apply fertilizer solution to each transplant, especially if fertilizer requirements during transplant production were from the media exclusively. Use a water-soluble fertilizer such as 10-34-0. Mix 1 quart of this material in 50 gallons of water. Apply about ½ pint per transplant. For more information on transplant production, consult Bulletin 1144, *Commercial Production of Vegetable Transplants*, or your local county Extension agent.

Table 1. Watermelon Transplant Guide

Type	Seed for 10,000 Transplants (lbs.)	Planting Depth (in.)	Cell or Container Size* (in.)	Time to Field (Weeks)	Germination Temperature Range (°F)	Days to Emergence	Optimum Growing Temperatures (°F)	
							Day	Night
Large seeded	3-4	½-¾	1-3	3-5	70-95	4-5	70-80	60-70
Small seeded	2-3	½-¾	1-3	3-5	70-95	4-5	70-80	60-70
Seedless	3-4	½-¾	1-3	4-6	85-95	5-6	70-80	60-70

* Container size depends on scheduling. For example, a 1-inch-by-1-inch container will not support a 7-week-old plant. Larger-sized cells should be used if you are planning on producing older transplants.

Plastic Mulch

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Growing vegetable crops on polyethylene (plastic) mulch has become a common practice in the Southeast. Watermelon is one of the crops that have done well on plastic. During the past 10 years, the acreage of Georgia watermelons on plastic has increased steadily from less than 1,000 to more than 10,000 acres.

Advantages of Plastic Mulch

Because plastic mulch warms the soil, watermelons on plastic can often be harvested 10 days to two weeks earlier than bare ground melons. Historically, buyers pay higher prices for earlier Georgia melons. For many growers, this potentially higher cash return justifies the additional costs of growing watermelons on plastic. In addition to promoting earliness, plastic mulch conserves soil moisture and helps prevent leaching of plant nutrients from watermelon beds. Black and wavelength-selective mulches block photosynthetically active radiation, thereby inhibiting or preventing weed growth. Unfortunately, plastic mulch does not control yellow and purple nutsedge.

Added Costs of Production on Plastic

The cost of plastic mulch can add substantially to production cost. Plastic mulch cost will vary depending on plastic type, thickness, width and row spacing. In addition, preparing the beds and laying the plastic requires specialized equipment. This represents a sizable investment for growers who do not already have the equipment. For some growers, a good alternative is to hire someone to lay the plastic customly. If nondegradable plastic is used, plastic removal and disposal result in additional costs. See this bulletin's *Production Costs* section for estimated plastic cost. Even though production costs are more on plastic, the potential for profit is substantially greater because of historically higher prices for early melons.

Drip Irrigation

Drip irrigation is an option for watermelons grown on plastic. It helps conserve water, provides water to the root zone without wetting the foliage and facilitates "spoon feeding" of nutrients through drip lines. However, drip irrigation increases cost of production.

Most Georgia watermelon growers who use plastic mulch do not use drip irrigation because they already have overhead irrigation capability (center pivot or traveling gun). For more information on drip irrigation see the *Irrigation* section of this bulletin.

Types of Plastic

Of the various colors and types of plastic (polyethylene) mulches, 1.25 mil black plastic is the most popular in Georgia. Black plastic effectively warms the soil and also prevents the growth of most weeds. Although clear plastic warms the soil, it is not recommended for watermelon production in Georgia because it doesn't provide weed control.

The use of degradable plastic mulches that breakdown over time is increasing in Georgia. If you plan to use degradable mulch for watermelon production in Georgia, select one that is formulated to remain intact for at least 45 to 60 days. Although degradable mulches cost more initially, they eliminate the cost of removal and disposal after the growing season. Degradable mulches having consistent and appropriately timed degradation rates are potentially beneficial, especially to growers who do not double-crop.

Although other vegetable crops require wider plastic, plastic mulched beds 18 to 24 inches wide are commonly used for watermelon production in Georgia. Because 4 to 6 inches are required on each side for covering (the tuck), 24- to 36-inch wide plastic is required (Figure 9).

Figure 9. *Watermelons growing on raised plastic mulch covered beds*

Plant Establishment and Spacing

Watermelons may be seeded or transplanted on plastic. Direct seeding of triploid seedless watermelons is not recommended. If transplants are used, apply about ½ pint of a transplant watering solution (containing 1 quart of 10-34-0 or similar material per 50 gallons of water) to each transplant to help get it off to a good start.

Watermelon spacing on plastic varies widely depending on the variety and the desired melon size. In general, 6 to 9 feet between-row spacings and 3 to 8 feet in-row spacings are used. Under good growing conditions, 30 to 40 square feet per plant is usually sufficient for producing watermelons weighing 18 to 21 pounds each. To produce heavier melons, space plants farther apart.

One popular spacing for mulched watermelons is 6 feet by 6 feet with a 9-foot middle after every fourth bed. This spacing is adequate for good yields of medium size melons and the 9-foot middles facilitate movement of equipment through the field during production and harvesting.

Young seedlings and transplants on plastic seem especially vulnerable to wind damage. The use of windbreaks is strongly recommended.

Fertilizer Application and Tissue Analysis

Lime and fertilizer rates should be based on soil tests. For plastic-mulched, overhead-irrigated watermelons, all the recommended fertilizer can be incorporated into the bed. Another popular option is to band or incorporate 25 percent to 50 percent of the recommended fertilizer in the bed prior to mulch installation and apply the remainder in two side-dress applications as needed. Periodic tissue analysis (approximately every seven to 10 days) provides baseline data that can help determine when and which nutrients need to be applied as the season progresses.

Sometimes, even with adequate bee activity, watermelon fruit set is less than satisfactory. Under these conditions, two or three foliar applications of boron at weekly intervals (beginning with first bloom) can enhance pollination and improve fruit set. Many growers who have melons on plastic routinely apply a calcium-boron spray, such as CaB™, according to label directions.

Growing Seedless Watermelons

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Although production of seedless watermelons (more correctly called triploid melons) is similar to production of seeded (diploid) melons, some differences exist:

- Triploid watermelon seed has more difficulty germinating and becoming established in the field.
- A pollenizer variety must be planted in the field with the triploid melons.
- A row of the pollenizer variety should be alternated with every two rows of triploid melons (Figure 10).

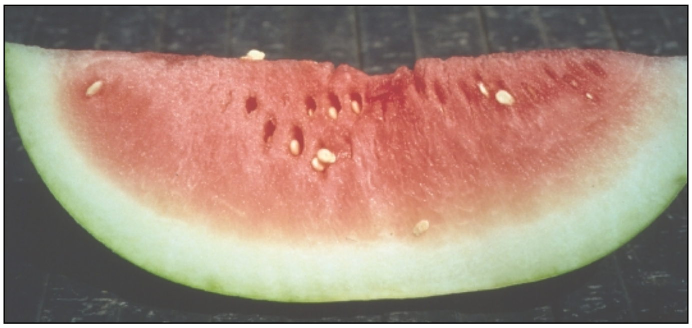

Figure 10. *Triploid or seedless watermelon. Note the visible seedcoats commonly seen in seedless watermelons. These seedcoats are edible and generally not found to be objectionable. An occasional hard 'true seed' is found routinely in seedless watermelons. For that reason, many growers and seed companies refer to seedless melons as triploid melons. Normal seeded melons are diploid.*

Field Seeding Not Recommended

Germination of triploid watermelon seed is inhibited at temperatures below 80° F. In addition, seedcoats of triploid watermelons are thicker than seedcoats of normal seeded watermelon seed. These thicker seedcoats tend to adhere to the cotyledons during emergence and damage plants or delay emergence. Because of the strict temperature requirements and the emergence problems associated with the thickened seedcoats, getting a satisfactory stand of triploid melons by direct seeding in the field is difficult. Because triploid seed is expensive (20 to 30 cents each), overseeding and thinning is not an option. To establish a seedless crop, transplant container-grown plants.

Pollenizer Variety

Growth-promoting hormones produced by the developing seed enhance fruit enlargement in seeded watermelons. Because triploid melons do not contain developing seed, they require pollen to stimulate fruit growth. This creates a problem because triploid plants are essentially sterile and produce little, if any, pollen. The solution is to interplant rows of seeded pollenizer melons with rows of triploid watermelons. Keep in mind that melons from the pollenizer variety must be easily separated from the triploid melons at harvest. Make sure the seeded melons are also acceptable to your buyers because about one-third of all the melons produced will be from the seeded pollenizer. It is especially important to ensure that sufficient numbers of bees are available for pollination. One strong hive (30, 000 to 50,000 bees) will usually pollinate 1 to 2 acres.

Frequency of Pollenizer Rows

Plant a row of the pollenizer variety on the outside bed. Follow the pollenizer row with two rows of the triploid variety and then put another row of pollenizer. This pattern should be repeated across the field.

Marketing Seedless Watermelons

Production costs for triploid watermelons are higher because:

- The seed is very expensive.
- The crop is established from transplants.
- Transplants of triploid melons are difficult to grow.
- A pollenizer variety must be interplanted with the triploid variety.

Growers must receive a premium price for triploid melons compared with conventional seeded melons. If you plan to grow triploid watermelons, make arrangements to market them at a premium before you plant them.

Diseases

J. Danny Gay, Extension Plant Pathologist

Diseases are important in determining the success or failure of watermelon production in Georgia. Certain diseases have destroyed entire watermelon crops in some areas when weather conditions favored their development. If disease control practices are not followed, some loss can be expected every year from foliage and stem diseases.

All watermelon foliage diseases spread in a similar manner. Some diseases can easily be brought into an area in or on the seed. Seed grown in dry, arid regions of the West have the best chance of being free of seedborne diseases. Locally grown seeds are more likely to be infested with diseases.

Disease-causing fungi can live from year to year on undecayed vines of watermelon, cantaloupe, cucumber, citrons, gourds and pumpkins. These fungi produce millions of spores on susceptible plants. The spores are sticky when wet; any time humans, animals or machines move through wet vines, these diseases can be spread. Splashing rain or runoff water can also spread these fungi from one area to another.

The amount of disease pressure in any given year is directly related to environmental conditions. Rain is the most important factor in the spread of foliage diseases. Under ideal weather conditions, some diseases can destroy entire fields within a few days. When weather forecasts predict extended rainy periods, you should consider applying a recommended chemical to control foliage diseases at least 24 hours before the rain is expected and again immediately after the rain.

Damping-off

Damping-off is caused by a seedling disease complex that usually involves *Phythium* spp., *Rhizoctonia* spp. or *Fusarium* spp. The amount of damping-off is usually directly related to litter from the previous crop and to environmental conditions. In some years, seedling diseases reduce stands by 50 percent; in other years, seedling diseases are rare. Good cultural practices and seed treatment are essential in preventing damping-off of young watermelon seedlings. Basically, conditions unfavorable for rapid emergence, which involves cool, wet weather, are usually most favorable for damping-off.

Root-knot Nematodes

Root-knot nematodes are small eel-like worms that live in the soil and feed on plant roots. Root-knot nematodes cause serious damage to watermelons when planted to infested fields. All species of root-knot nematodes are capable of causing serious damage to watermelons. The lack of a good, easy-to-use nematicide for watermelons makes the worms a major problem. Although fumigants are excellent for reducing nematode populations, the waiting period required after application can cause delays in planting; therefore, plan ahead if fumigation is to be used. Nematodes impair the root system so the plant cannot take up water and nutrients; moreover, they allow diseases like Fusarium wilt to enter the plant. Serious root-knot injury usually appears as stunted, wilted growth in the above ground part, with a galled root system becoming progressively worse during the growing season. Potential watermelon fields should be inspected for root-knot nematodes before the crop is planted (Figure 11).

Gummy Stem Blight

Gummy stem blight is caused by the fungus *Didymella bryoniae.* During the past few years, this has been the most serious disease affecting watermelons in Georgia. This fungus can cause damping-off, crown rot, leaf spot, stem canker and fruit rot of watermelons. Lesions on the cotyledons and leaves are round or irregular and brown in color. Lesions on the crown and stem are brown and usually turn white with age. Early infection usually comes from diseased seeds. On older leaves, brown to black spots develop between the leaf veins. The first spots usually occur in the lobes of the leaves. Gummy stem blight spreads from the center of the plant outward. As the season advances, gummy stem blight attacks vines, causing elongated, water-soaked areas that become light brown to gray. Vine cankers are most common near the crown of the plant. Gum oozes from stem cracks, and runners usually die one at a time. It is unusual to find gummy stem causing fruit rot in watermelons (Figure 12).

Anthracnose

Anthracnose, caused by the fungus *Glomerella cingulata* var. *orbiculare (Colletotrichum lagenarium, C. orbiculare),* can be a destructive disease of watermelons. This fungus attacks all above ground parts of the watermelon plant. Plants can be infected at any stage of growth; disease symptoms are first noticed as round to angular reddish brown spots on the oldest leaves. Spots may later dry, turn almost black and tear out, giving the leaf a ragged appearance. Often the leaves at the center of the plant die first, leaving the stem and a portion of the runners bare. Light brown to black elongated streaks develop on the stems and petioles. After a few days of warm, rainy weather, every leaf in an entire field may be killed, giving the field a burned over appearance.

Round, sunken spots may appear on the fruit. Spots first appear water-soaked, then turn a dark green to brown color. The pinkish-colored ooze often noticed in the center of the sunken spot is spores of the fungus. There are three types of the anthracnose fungus, known as races 1, 2 and 3. In recent years, Race 2 has become widespread in Georgia. It has severely damaged watermelon varieties that have previously shown anthracnose resistance. In areas where all three races of the fungus are present, no variety is resistant to anthracnose (Figure 13).

Fusarium Wilt

The fungus *Fusarium oxysporum* f.sp. *niveum* causes Fusarium wilt of watermelons. Fusarium wilt is widespread in many fields in Georgia. Symptoms can occur at any stage of growth. Infected plants develop wilt symptoms on one or more runners, usually beginning at their tips. The vascular tissue in the lower stem and roots develops a light brown discoloration. In severe cases, the entire root may become dark brown and a soft rot develops near the crown. The pathogen can spread to new areas on seed or in soil transported by equipment, drainage water and man. Several varieties are considered somewhat resistant to this disease. However, even with resistant varieties it is desirable to use new land or have a minimum of eight years between diseased crops on the same land. On old land, some wilting can occur even with resistant varieties; final thinning should be delayed as long as possible to eliminate the great number of wilt-susceptible plants before the final stand is established. Contamination of new fields with soil from Fusarium infested fields should be avoided. (Figure 14).

Downy Mildew

Downy mildew is caused by the fungus *Pseudoperonospora cubensis*. This fungus attacks only the leaves of watermelons. Lesions first appear on the oldest crown leaves as yellow, mottled spots with indefinite borders blending gradually into healthy portions of the leaf. Older lesions are dark brown with a slight yellow border. As the disease progresses, brown areas coalesce, causing leaves to curl inward toward midribs. Under favorable conditions for disease development, downy mildew develops rapidly, resulting in a scorched appearance over an entire field. The pathogen is airborne and usually begins in areas south of Georgia and moves up the coast destroying watermelons in its path. Downy mildew has not been a problem in watermelons in the last several years; however, the potential is there, and plantings should be observed frequently for signs of downy mildew (Figure 15).

Watermelon Mosaic Virus

Watermelon mosaic virus I and II are now known as papaya ringspot virus—watermelon type (PRSV-W) and watermelon mosaic virus (WMV), respectively. These are two common viruses found on Georgia watermelons. Several other viruses affect watermelon; all have similar symptoms. The most common symptom is mottling of the leaf. However, mottling may be difficult to see under certain weather conditions. Some plants are stunted with abnormal leaf shapes, shortened internodes and bushy erect growth habits of some runner tips. The first symptom on the fruits is usually a bumpy and mottled appearance of the fruit surface. This disease symptom is strongly expressed in periods of extended high temperatures, which occur just before watermelon harvests in Georgia. These viruses are spread by aphids, which can spread through an entire planting during the growing season (Figure 16).

Rind Necrosis

The cause of rind necrosis is not known. However, it is reported in association with bacteria such as *Erwinia* spp. The symptom of this disease is the development in the rind of light brown, dry, corky spots, which may enlarge and merge to form rather extensive necrotic areas that rarely extend into the flesh. Although there are no external symptoms of rind necrosis, infected fruits appear to have exceptionally tough rinds. It is not known how this disease is transmitted, but it apparently is limited to fruit infection. Watermelon varieties differ in the relative incidence and severity of rind necrosis (Figure 17).

Fruit Blotch

Fruit blotch is caused by the bacterium *Acidovorax avenae* subsp. *citrulli*. The fruit blotch bacterium can cause seedling blight, leaf lesions and fruit symptoms.

First symptoms in watermelon seedlings appear as dark water soaking of the lower surface of cotyledons and leaves followed by necrotic lesions, which frequently have chlorotic halos. In young seedlings, lesions can occur in the hypocotyl, resulting in collapse and death of the plant. Leaf lesions are light brown to reddish-brown in color and often spread along the midrib of the leaf. Leaf lesions in the field do not result in defoliation, but are important reservoirs of bacteria for fruit infection.

Symptoms on the surface of fruit begin as small, greasy-appearing water-soaked areas a few millimeters in diameter. These enlarge rapidly to become dark-green, water-soaked lesions several centimeters in diameter with irregular margins. Within a few days, these lesions may rapidly expand to cover the entire surface of the fruit, leaving only the groundspot symptomless. Initially, the lesions do not extend into the flesh of the melon. With age, the center of the lesions may turn brown and crack, and a fruit rot may develop. White bacterial ooze or effervescent exudate follows fruit decay. Fruit blotch bacteria may be introduced into a field by infested seed, infected transplants, contaminated volunteer watermelons or infected wild cucurbits (Figure 18).

Figure 11. *Root-knot nematode damage*

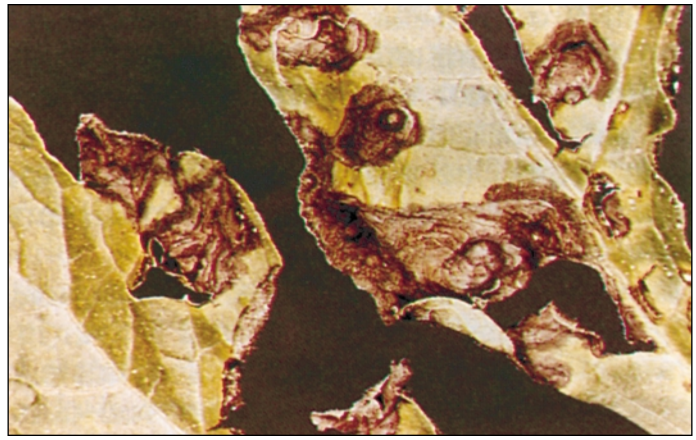

Figure 12. *Gummy stem blight*

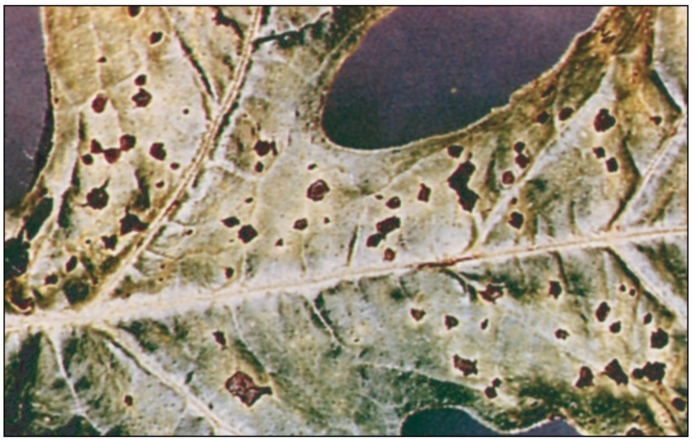

Figure 13. *Anthracnose*

Figure 14. *Fusarium wilt*

Figure 15. *Downy mildew*

Figure 16. *Watermelon mosaic virus*

Figure 17. *Rind necrosis*

Figure 18. *Watermelon fruit blotch*

Insect Management

David Adams, Extension Entomologist

Watermelons are subject to attack by a variety of insect pests. These attacks do not always result in economic injury, so certain insect management practices can be used to ensure cost-effective control decisions. Indiscriminate use of insecticides often creates more favorable conditions for the development of harder-to-control insect pests, thus increasing the cost of production.

Insects cause injury to the leaves, stems, roots and melons. The developmental stage of the plant at the time of attack often governs the plant part injured by different insect pests. However, some insects feed specifically on one plant structure; others may feed on several structures.

Certain cultural practices may have a dramatic effect on the potential for economic injury by certain insects. Planting during optimum growing conditions ensures rapid seedling emergence and subsequent growth. This reduces the amount of time that plants are susceptible to injury from seedling insect pests.

Spring plantings that are harvested by early July often escape the period of time that certain insect pests pose their greatest economic threat. Migratory species, not indigenous to Georgia, do not build large populations until July or later. Disease-vectoring species, even though present in the spring, are often a more serious threat to later plantings.

Most insect problems can be treated as needed if detected early, but no one insecticide will adequately control all the insects that may attack watermelon. Scouting for insects is the most efficient way to determine what problems may exist and what action should be taken.

Preventive treatments may be necessary for certain insect pests. Preventive treatments are used against insects that are certain to cause economic injury if they are present. Field history, harvest dates and insect pressure in nearby production areas influence preventive treatment decisions.

Root Maggots

The seedcorn maggot, *Hylemya platura*, is the predominant species of root maggot found in Georgia's major watermelon production areas. The adult is a fly similar to the housefly, only smaller. It has many bristles on the body. The larvae or maggot is creamy white, ¼ inch long at maturity and legless. The body tapers sharply from rear to head.

The maggot is the damaging stage. Root maggots tunnel in the seeds or the roots and stems of seedlings. Seeds usually succumb to secondary rot organisms and fail to germinate after attacks. Seedlings often wilt and die from lack of water uptake. Seedlings that survive are weakened and more susceptible to other problems.

Cool, wet conditions favor the development of root maggot infestations. Early plantings are therefore most subject to attack. Egg-laying adults are attracted to soils with high organic matter. Even though soils in Georgia are characteristically low in organic matter, it still presents problems. Dead or dying organic matter such as weeds or previous crop residue attracts the flies.

Greenhouse-grown transplants are raised in high organic soil mixtures that attract the flies in the greenhouse environment. Eggs may be laid on the soil while the plants are in the greenhouse. The eggs may hatch after the transplants are placed in the field, and the maggots attack and kill the seedlings.

Several practices may be used to help control maggots. Previous crop litter and weeds should be turned deeply several weeks prior to planting so there is adequate time for decomposition. Plant during optimum conditions for rapid germination and seedling growth. Early plantings should be preceded by incorporation of a recommended soil insecticide. Plants should be maintained stress free until they are beyond the seedling stage (Figure 19)

Wireworms and Whitefringed Beetle Larvae

Wireworms, mostly *Conoderus* spp., and whitefringed beetle (WFB) larvae, *Graphognathus* spp., can reduce stands dramatically if present in even moderate numbers (one per square yard). Wireworms are less likely to affect early planting because they are relatively inactive during the early spring.

The WFB adults (weevils) are not important in watermelons. Larvae are creamy white and legless. They grow to about ½ inch long and are C-shaped grubs. The mouthparts are dark brown, pincher-like structures that are highly visible. The head capsule is slightly recessed and blends so well with the rest of the body that it looks headless.

Whitefringed beetle larvae pass the winter in the larval stage and may be active even during the milder winter months. Presently, no effective insecticides are labeled for control of this insect. If WFB larvae are found (one per square yard) during land preparation, do not plant the field in watermelon (Figure 20).

Cucumber Beetles

Several species of cucumber beetles may attack watermelon. The most common species found in Georgia are the spotted cucumber beetle, *Diabrotica undecimpunctata*, and the striped cucumber beetle, *Acalymma vittata*. The banded cucumber beetle, *Diabrotica balteata*, is found occasionally.

Cucumber beetles sometimes are mistaken for lady beetles, which are beneficial predators. Cucumber beetles are more oblong than lady beetles, which are nearly circular. The spotted cucumber beetle adult is about ¼ inch long with 11 black spots on its yellowish-green to yellow wing covers. The banded cucumber beetle is slightly smaller than the spotted cucumber beetle. The banded cucumber beetle is yellow with three black stripes on the back.

The larvae of the different cucumber beetles are very similar and live underground. Larvae are creamy, yellowish-white, soft-bodied worms with three pairs of inconspicuous legs. Mature larvae of the spotted cucumber beetle may be from ½ to ¾ inch long. The striped cucumber beetle larvae are slightly smaller. Both larvae have a dark brown head and a dark brown plate on the last body segment.

Beetles and larvae may damage watermelon. The beetles have been responsible for most economic damage. Beetles feed on the stems and foliage of the plant. Beetles feed on the stems until the plants become less attractive because of hardening, after which more foliage damage will be apparent. Feeding begins on the undersides of the cotyledons or true leaves. If beetle populations are high during the seedling stage, stand reductions can occur.

Larvae may feed on all underground plant parts and usually cause insignificant amounts of damage. Occasionally, larvae cause direct damage to the melon. This is more likely to occur during excessive moisture conditions when the larvae feed on that portion of the melon in direct contact with the soil surface. The damage consists of small trail-like canals eaten into the surface of the rind. The most severe consequence of larval damage is the introduction of secondary disease organisms.

Cucumber beetles can be controlled with foliar applications of insecticides when 10 percent or more of the seedlings are infested. The natural feeding behavior of cucumber beetles leads to their avoidance of insecticidal sprays, so thorough spray coverage is imperative. The most cost-effective application method is to band over-the-top and direct sprays to the base of the plant. There are no recommendations for control of the larvae (Figure 21).

Aphids

The melon aphid, *Aphis gossypii*, and the green peach aphid, *Myzus persicae* are common in Georgia melons. Aphids are soft-bodied, oblong insects that rarely exceed 3/32 inch long. Adults may be winged or wingless, most often wingless. Aphids have two exhaust-pipe-like structures called cornicles on the rear of the abdomen. Immature aphids are wingless and look like the adults, only smaller.

Aphids are slow-moving insects that live in colonies on the undersides of leaves. Aphids feed on the leaves with their piercing-sucking mouthparts. As they remove plant sap, the leaves curl downward and take on a puckered appearance. Heavy populations cause plants to yellow and wilt. Aphids secrete a substance known as honeydew, which collects on the surface of the lower leaves. Under favorable conditions, the honeydew provides the sustenance for the growth of sooty mold, a fungus that blackens the leaf surface. This reduces photosynthesis, thereby reducing quality and/or yield.

The greatest damage caused by aphids is indirect. Aphids vector several viruses that can reduce melon quality. For this reason, aphid populations should be kept to a minimum. Winged aphids are the primary vectors of such diseases and should be monitored two to three times per week until melons are full size.

Several insecticides are effective on light to moderate populations of aphids. If winged aphids are found easily (10 percent of plants infested), treatment is warranted. Thorough coverage is essential because aphids live on the undersides of leaves (Figure 22).

Thrips

Several species of thrips may inhabit watermelon fields, but they are not very well understood as pests. Thrips are very small, spindle-shaped insects, 1/10 inch or less in length. Immature thrips are wingless; the adults have wings with hairlike fringe.

The thrips that cause early foliage damage often are different from those present during the period of heavy fruit set in spring plantings. The most noticeable damage is to the foliage. Narrow bronze lesions appear on the leaf surface. The entire field may have a silvery appearance from heavy feeding. This damage is caused by the thrips rasping the leaf surface before its expansion. The most severe damage occurs during the periods of slow growth. Damage is quickly outgrown during periods of rapid growth; usually no treatment is required.

The western flower thrips (WFT), *Frankliniella occidentalis*, is the species most common during rapid fruit set. WFT is a species two to three times larger than the common onion and tobacco thrips often found infesting early plantings. Whether WFT or any other species causes any significant damage to the melon is not well known. Thrips mechanically damage plants during the feeding process. If thrips were to feed on pre-pollinated melons, the damage would not be noticeable until the melons were larger. Physical damage of this type would appear as catfacing, light russeting or other deformities on the rind surface.

Thrips can be controlled with foliar insecticide applications. No treatment thresholds have been developed for thrips. As a rule of thumb, treatments generally are not necessary if thrips are damaging only the foliage. Treatments for thrips during early fruit development may be initiated when a majority of the blooms are infested with large numbers of thrips—75 or more per bloom (Figure 23).

Cutworms

The granulate cutworm, *Feltia subterranea*, is the predominant species in the Coastal Plain of Georgia. The adult is a nondescript moth. Larvae are greasy-looking caterpillars that may be 1½ to 1¾ inches long at maturity. Young larvae may be pinkish-gray; older larvae are usually dingy gray. A series of chevrons slightly lighter gray than the body runs along the back.

Cutworms feed at night and remain inactive during the day, either on the soil surface or below ground. Cutworms may attack all plant parts, but the most severe damage occurs when they feed on young seedlings or developing melons. Cutworms damage young plants by chewing on the stem slightly above or below ground. Stand reductions may occur. Damage to the melon is often confined to the rind. Rind damage may be superficial. Cutworm feeding results in trails or patches of tan to russet callus tissue.

Cutworms can be difficult to control, but understanding their behavior can help. Cutworms pass the winter months in the larval stage. This means that the larvae may be present at the time of planting. In these cases, stand reductions will be likely. Inspect fields during land preparation and just before and during the planting operation. If cutworms are found, treatments should be made either by incorporation of a soil insecticide or a directed spray if plants are already present. Foliar sprays should be made as late in the day as possible to coincide with the greatest larval activity. (Figure 24)

Pickleworms and Melonworms

The pickleworm, *Diaphania nitidalis*, and melonworm, *D. hyalinata*, are migratory insects that overwinter in areas from southern Florida to South America. Watermelon is one of their least preferred hosts in the cucurbit group. Plantings of watermelons that are harvested by early July are unlikely targets. Extremely late plantings are subject to attack and should be monitored for developing infestations (figures 25, 26, 27).

Rindworms

"Rindworm" is a term that describes any worm that may attack the rind of the melon. It does not refer to a specific species. The most common worms that may fit this description are cutworms, corn earworms, loopers, and beet and fall armyworms. When the rind is attacked, the insect must be identified correctly because no one insecticide will control all of the aforementioned species (Figure 24).

Miscellaneous Insect Pests

Some insects become pests of watermelons only if a preferred host is not available, populations are very high, or environmental conditions are just right for rapid development. Flea beetles, spider mites, leaf miners, stink bugs, leafhoppers, squash bugs and grasshoppers are just a few. These problems can be addressed on a case-by-case basis. Contact the local county Extension agent with any questions on the treatment of these insects.

Honeybees

Honeybees are necessary to ensure adequate pollination. Because most insecticides are toxic to honeybees, certain practices should be followed to prevent bee kills. Honeybees may be active from dawn to dusk. Insecticide applications should be made late in the day, after sunset if possible, after bee activity has ceased. If a large acreage must be sprayed during the day, remove hives from the field the preceding day. If these precautions are followed, bee kills will be kept to a minimum. Once dried on the leaf surface, the toxic effects of most insecticides are dramatically reduced.

Figure 19. *Root maggots*

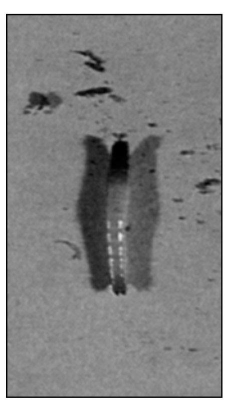

Figure 20. *Wireworm (left), whitefringed beetle larvae*

Figure 21. *Spotted cucumber beetle (left), striped cucumber beetle and stem damage (middle), cucumber beetles and foliage damage*

Figure 22. *Colony of aphids*

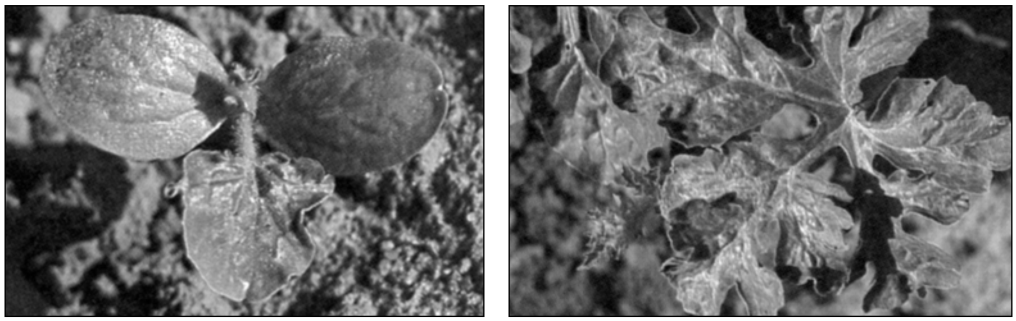

Figure 23. *Thrips damage, seedling (left); thrips damage, mature leaf*

Figure 24. *Cutworm (rindworm) damage*

Figure 25. *Melonworm*

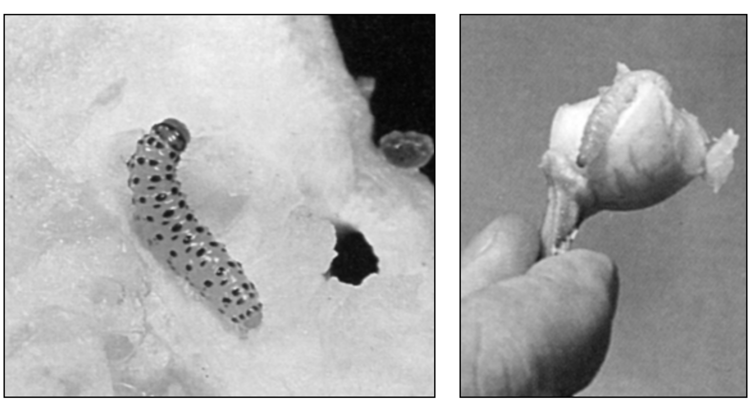

Figure 26. *Pickleworm, young larva (left); pickleworm, mature larva*

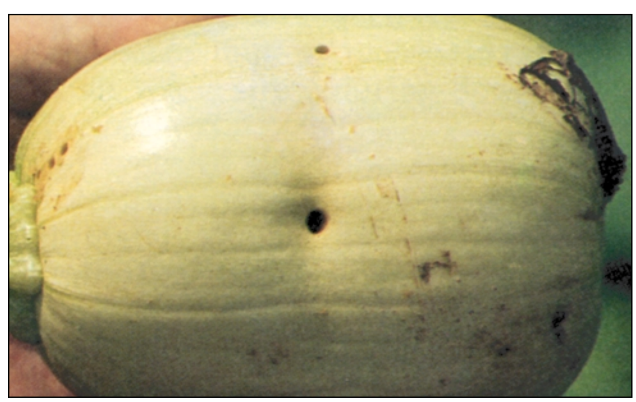

Figure 27. *Pickleworm damage*

Pesticide 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 28) use a conventional hydraulic nozzle; air forces the spray into the plant foliage. Boom sprayers (Figure 29) 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.

Pumps

Three factors to consider in selecting the proper pump for a sprayer are:

1. **Capacity.** The pump should be of proper capacity or size to supply the boom output and to provide for agitation (5 to 7 gallons per minute (gpm) per 100-gallon tank capacity). Boom output will vary depending upon the number and size of nozzles. Allow 20 percent to 30 percent for pump wear when determining pump capacity. Pump capacities are given in gallons per minute.
2. **Pressure.** The pump must produce the desired operating pressure for the spraying job. Pressures are indicated as pounds per square inch (psi).
3. **Resistance to corrosion and wear.** The pump must be withstand the chemical spray materials without excessive corrosion or wear. Use care in selecting a pump if wettable powders are to be used because these materials will accelerate pump wear.

Before selecting a pump, consider factors such as cost, service, operating speeds, flow rate, pressure and wear. 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 related to pesticide applications. The type of nozzle determines not only the amount of spray applied but also the uniformity of the applied spray, 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 watermelons 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 to 30 psi for all except drift reduction and turbo drop flat fans, flooding fans and wide angle cones. Spray pressure more than 40 psi will create significant drift with flat fan nozzles. Drift reduction and turbo drop nozzles should be operated at 40 psi. Flooding fan and wide angle cone nozzles should be operated at 15 to 18 psi. These nozzles will achieve uniform application of the chemical if they are uniformly spaced along the boom. Flat fan nozzles should overlap 50 percent to 60 percent.

Insecticides and Fungicides

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

Figure 28. *Air-assisted sprayer*

Figure 29. *Hydraulic boom sprayer*

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 resist corrosive or abrasive materials excellently. Plastic tips are resistant to corrosion and abrasion and are proving to be very economical for applying pesticides. Brass tips have been common but wear rapidly when used to apply abrasive materials such as wettable powders. Brass tips are economical for limited use, but other types should be considered for more extensive use.

Water Rates (GPA)

The grower who plans to use spray materials at the low water rates 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 sprayers. When applying pesticides that tend to settle out, continuous agitation is needed even when moving from field to field or when stopping for a few minutes.

Nozzle Arrangements

When applying insecticides and fungicides, it is advantageous to completely cover both sides of all leaves with spray. When spraying watermelons, use one or two nozzles over the top of the row (up to 12 inches wide). Then as the plants start to spread, place nozzles on 10- to 12-inch centers for broadcast spraying.

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 1 gallon contains 128 ounces of liquid, 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. Replace with new nozzles if necessary. When applying materials that are appreciably different from water in weight or flow characteristics, such as fertilizer solutions, calibrate with the material to be applied. Exercise extreme care and use protective equipment when an active ingredient is involved.

1. From Table 2, determine the distance to drive in the field (two or more runs suggested). For broadcast spraying, measure the distance between nozzles. For band spraying, use band width. For over-the-row or directed sprays, use row spacing.
2. Measure the time (seconds) needed to drive the required distance with all equipment attached and operating. Maintain this throttle setting!
3. With the sprayer sitting still and operating at the same throttle setting or engine RPM as in Step 2, adjust the pressure to the desired setting. The 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. 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. 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.
5. 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 the recommended rate. If speed is adjusted, start at Step 2 and recalibrate. If pressure or nozzles are changed, start at Step 3 and recalibrate.

Table 2. Distance to Measure to Spray $^1/_{128}$ Acre
One ounce discharged equals 1 gallon per acre.

Nozzle Spacing (inches)	Distance (feet)
6	681
8	510
10	408
12	340
14	292
16	255
18	227
20	204
22	186
24	170
30	136
36	113
38	107
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-inch band = 340 / $^{13}/_{12}$ = 313 feet

Irrigation

Anthony W. Tyson and Kerry Harrison, Extension Engineers

Water is a critical component in the production of watermelons. A ripe watermelon consists of more than 90 percent water (a 30-pound watermelon contains more than 3 gallons of water). Thus, an adequate water supply is critical to optimizing yield and quality of this crop.

Watermelons are potentially deep rooted (4 to 6 feet); however, in Georgia soils, the effective rooting depth is generally much less. Actual rooting depth will vary considerably depending on soil conditions and cultural practices. The restricted rooting depth and the fact that watermelons are commonly grown in sandy soils with a low water-holding capacity make irrigation necessary for consistently high yields of quality watermelons in Georgia.

Water deficits during the establishment of watermelons delay maturity and may cause gaps in production. Water stress in the early vegetative stage results in reduced leaf area and reduced yield. The most serious yield reductions result from water stress during flowering and fruit development.

Several types of irrigation systems may be used successfully on watermelons in Georgia. Ultimately, the decision about which type to choose will be based on one or more of the following factors:

- availability of existing equipment
- field shape and size
- amount and quality of water available
- labor requirements
- fuel requirements
- cost

Sprinkler Irrigation

Currently, most watermelons are irrigated with some type of sprinkler irrigation. These systems include center pivot, linear move, traveling big-gun, permanent set and portable aluminum pipe with sprinklers. Any of these systems are satisfactory, if they are used correctly. However, significant differences exist in initial cost and labor requirements.

Any sprinkler system used on watermelons should be capable of delivering at least an inch of water every four days. In addition, the system should apply the water slowly enough to prevent run-off. With most soils, a rate less than 2 inches per hour safely prevents runoff.

Sprinkler systems with a high application uniformity (center pivot and linear move) can apply fertilizer through the system. This increases the efficiency of fertilizer use by making it readily available to the plant and reduces leaching.

Although overhead irrigation is not recommended with plastic mulch, when it is employed, a narrow plastic mulched bed (12 to 24 inches) is better because water can reach the roots more easily. Wider beds (greater than 24 inches) may be more problematic, particularly on sandy soils where lateral water movement is restricted.

Drip Irrigation

Drip irrigation is gaining popularity for production of watermelons. It can be used with or without plastic mulch. One of the major advantages of drip irrigation is its water use efficiency if properly managed. Studies in Florida have indicated that 40 percent less water was required over the growing season for drip irrigated vegetables than for sprinkler irrigated vegetables. Weeds are also less of a problem because only the rows are watered and the middles remain dry. Some studies have indicated that drip also enhances early yield and fruit size.

Drip tubing (or tape) may be installed on the ground surface or buried just below the surface. When used in conjunction with plastic mulch, the tape can be installed at the same time the plastic mulch is laid. It is usually desirable to offset the tape slightly from the center of the bed. This prevents the tape from being damaged during the hole punching and the planting operation. Typically, one line of drip tape is installed beside each row. A field with 6-foot row spacing will require 7,260 feet of tape per acre.

Tape is available in various wall thicknesses ranging from 4 mils to 25 mils. Most growers use thin wall tape (less than 10 mils) and replace it every year. Heavier wall tape can be rolled up at the end of the season and reused; however, care must be taken in removing it from the field.

Drip systems can easily be adapted for fertilizer injection. This allows plant nutrients to be supplied to the field as needed. This method also eliminates the need for heavy early-season fertilizer applications, which tend to leach beyond the reach of root systems or cause salt toxicity problems. Only water-soluble formulations can be injected through the drip systems. The system should be thoroughly flushed following each injection.

Water used in a drip irrigation system should be well filtered to remove any particulate matter that might plug the tape. The water should be tested for minerals that might cause plugging problems.

Scheduling Irrigation

The water used by a crop and evaporated from the soil is called evapotranspiration (ET). ET rates for watermelons have been reported as high as 0.3 inches per day. Stage of crop growth, temperature, relative humidity, solar radiation, wind and plant spacing affect ET.

The following is a general recommendation for irrigation rates on sprinkler irrigated watermelons:

- **From planting until plants begin to run,** apply ½ inch whenever soil in top 6 inches becomes dry (about every five or six days when weather is dry).
- **From time plants begin to run until first bloom,** apply ¾ inch every five days during dry weather. If wilting occurs before noon, increase frequency of irrigation
- **From first bloom until harvest,** apply 1 inch every four days during dry weather. During extremely hot weather (more than 95°F), frequency may need to be increased to every three days to avoid stress.

Sandy soils may require more frequent, lighter applications than heavier soils to prevent moisture stress.

Drip irrigation systems need to be operated more frequently than sprinkler systems. Typically, they are operated every day or every other day. Do not overwater, especially when using plastic mulch, because the plastic will keep the soil from drying out.

Soil moisture monitoring can be used to fine-tune irrigation applications. This ensures that soil moisture is adequate to prevent crop stress. The irrigation schedule should be adjusted whenever soil moisture measurements indicate overly wet or dry conditions.

Soil moisture may be monitored using either electric resistance blocks (such as the Watermark™ soil moisture sensor) or tensiometers. Install two sensors at each monitoring location: one about 8 inches deep and one about 16 inches deep. Each field should have a minimum of two monitoring locations; more for fields larger than 20 acres or if soil types vary considerably.

The 8-inch sensors are near the middle of the root zone and will indicate when irrigation should be started. Up until first bloom, readings should not exceed 50 centibars. Afterward, they should not exceed 30 centibars. The optimum range for soil moisture is 5 to 30 centibars depending on the soil types and the amount of available soil moisture desired. The 16-inch sensor evaluates previous irrigations. If readings remain low (less than 5 centibars), irrigation amounts should be decreased. If they continue to increase even after an irrigation, irrigation amounts should be increased. Read soil moisture sensors at least three times per week during dry weather.

Weed Control in Watermelons

Greg MacDonald, Extension Weed Scientist

Successful weed management is vital to the production of quality watermelons. Weeds compete with the crop for light, space, nutrients and, particularly, water. Weed growth promotes disease problems and can harbor deleterious insects and diseases. Weeds also impair the ability to harvest effectively, reducing the quantity of marketable fruit and increasing labor costs. Watermelons, as with most crops, require early season weed control to ensure a quality crop. In addition, the spreading nature of this crop makes weed control difficult once the vines begin to form.

Factors Affecting Weed Control

One of the most important factors to consider when growing watermelons is site or field selection. Fields heavy in Texas panicum, sicklepod, cocklebur and other difficult-to-control species should be avoided. In addition, perennial weeds such as nutsedge or Bermuda grass will cause problems and can be extremely hard to control. With perennial weeds such as these, frequent disking or mechanical disturbance prior to planting may reduce the severity of infestation. Nonselective herbicides may also be used to reduce perennial weeds.

Weed identification, especially seedling weeds, is also important. Seedling weeds are generally easier to control and in many cases control can occur only at the seedling stage.

Another important factor is the growth of the crop. Generally, an aggressive, healthy crop will outcompete and exclude many weeds. Proper fertilization as well as disease, nematode and insect management will promote crop growth and aid in weed suppression.

Methods of Weed Control

Several methods of weed control exist for watermelons. Selecting the method best suited for an individual grower will depend on several factors: weed species, stage of crop and weed development, and labor cost and its availability.

Hand weeding provides very effective weed control and is safe to the crop. Weeding should be performed when the crop and weeds are small to reduce crop damage and to allow hoeing. Removal of large weeds with extensive root systems may damage crop roots or vines. Hand weeding, however, is costly in terms of labor.

Mechanical cultivation provides very effective weed control but is limited to small weeds that can be easily uprooted or covered. More importantly, mechanical cultivation should not be performed once the plants have begun to vine ("run"). These vines are very tender and are easily damaged by tractor wheels or cultivators. Mechanical control must be supplemented with chemical or hand weeding to remove weeds in the rows or after the plants produce vines.

Chemical weed control is limited to herbicides recommended by the University of Georgia Cooperative Extension Service (see *Georgia Pest Control Handbook*). Although the *Georgia Pest Control Handbook* collectively includes weed control information on all cucurbit crops, herbicide use and tolerance varies among these crops. Furthermore, some differing tolerance has been noted between varieties of the same crop.

Weed control using the stale seedbed technique involves chemical weed control of emerged weeds before crop emergence. A nonselective contact material is used. The stale seedbed method often is coupled with a preplant-incorporated herbicide treatment. If the crop is transplanted, this method may be used to kill emerged weeds before transplanting. On direct-seeded plantings, apply the herbicide to those weeds that have emerged after planting but before the crop has emerged.

Fumigation will provide substantial weed control but is expensive and dangerous and must be performed by trained personnel. To ensure proper fumigation, a non-porous material such as plastic covers the soil. The fumigant is placed under the plastic, and the edges are sealed with soil. The length of time the cover remains in place varies with fumigant but is generally three days. When planting into plastic mulch after fumigation, allow at least three weeks for the chemical to disperse to avoid crop injury. Most small-seeded broadleaves and grasses will be controlled, but larger seeds and nutsedge tubers will not.

Plastic mulch with drip irrigation is a very effective method of weed control. Black or non-light-transmitting plastic is preferred, eliminating light required for weed germination and growth. This will eliminate most weeds except nutsedge. The tightly folded and pointed leaves of this species will penetrate the plastic and emerge. Plastic that covers the plant beds should fit tightly and seal the edges to prevent wind disturbance. Once the bed is covered, a small hole is made in the plastic and the transplant or seeds inserted. The smallest hole possible is advantageous to eliminate weed emergence. Those areas between the beds should be treated only with a herbicide registered for the crop, because the crop roots may extend into the row middles and contact the treated soil.

Harvest and Handling

William C. Hurst, Extension Food Scientist

Field Maturity

Watermelons are considered optimum for eating when their flesh matures to produce a sweet flavor, crisp texture and deep red color. Some newer cultivars, however, range in color from light red to yellow. Determining maturity of melons without tasting each is not easy. External rind appearance does not always predict good internal flesh quality and full maturity.

***Figure 30.** Use a hand refractometer to measure sweetness.*

Because of consumer demand for sweet, flavorful watermelons, total sugar content is an important quality factor. One way to determine field maturity before harvest is to cut a few melons taken from random parts of the field and test their sugar level using a hand refractometer (Figure 30). High quality watermelons should have a sugar content (measured as soluble solids) of 10 percent or more in the flesh near the center of the melon.

Time between harvest and consumption is a critical factor in determining when to harvest watermelons. Melons bound for distant markets are harvested when mature, but before full ripeness, to minimize handling damage and breakdown in texture that they can suffer in transit. Watermelons should be consumed within two to three weeks after harvest, primarily because of loss of crispness.

Selecting mature melons, ripe for harvest, is most difficult early in the season. Immature melons are characterized as being very firm, not yielding to pressure and having flesh colors of white to pink. If harvested immature, red color will develop, but the flesh will never develop acceptable sweetness, because sugar content does not increase after harvest.

Watermelons should be harvested before vines become withered, in which case the fruit is overmature. Overmaturity is characterized by flesh mealy in texture and reddish-orange in color.

Several maturity indicators help determine when to harvest watermelons. No single indicator is absolute for determining ripeness, because maturity differs with variety, location and plant growth. Look for a combination of these signs of maturity for best results:

- Tendrils or pigtails on vines nearest the fruit are wilting and have changed color from green to brown (Figure 31).
- The ground spot on the belly of the melon has changed from white to light yellow.
- The thumping sound changes from a metallic ringing when immature to a soft hollow sound when mature.
- The green bands (striped varieties) gradually break up as they intersect at the blossom end of the melon.
- Ribbed indentations, which can be felt with the fingertips, occur along the elongated body (Charleston Grays).

***Figure 31.** A brown tendril next to fruit (right) indicates maturity; a white tendril, immaturity.*

Harvesting

Before planning watermelon harvest operations, consider:

- buyer's requirements
- availability of labor
- equipment for harvesting, grading and packing
- availability of trucks for transportation to market.

Harvesting and handling costs are much higher than growing costs. Therefore, melons must be harvested at the right stage of maturity and handled gently enough to avoid damage to ensure market quality.

Watermelons should be cut from the vine rather than pulled, twisted or broken off. Pulling stems out provides an entrance for bacteria and fungi that can cause souring and can decay the internal flesh. As melons are cut from their vines, the bottoms, which are subject to sunscald, should be turned down. Cutters should carefully lay melons at the edge of roadways in the field for loaders to pick up and pass to stackers in a field truck. The typical field harvesting crew may range from nine to 12 people, including two to three cutters, four to six loaders, two stackers and one truck driver. Field trucks haul melons out of the field to waiting over-the-road tractor-trailers for bulk loading or to nearby packing sheds for bin and carton loading.

Handling

Rough handling due to carelessness and haste during harvest will cause damage and quality loss. Loaders on the ground should hand pass melons to stackers who carefully place them in the load. Pitching melons often results in their being dropped or rolled onto the load (Figure 32). Never stack melons on their ends, because the thin blossom end is the most susceptible area for bruising. A drop of only 8 inches can result in severe internal bruising; a 1-foot drop can crack the flesh internally or split the melon open.

Figure 32. *Damage results when loaders pitch melons on top of the field load.*

Bruising and abrasion result when loaders throw melons into the truck on top of other melons. Cutters should take care not to skin or scuff melons with their knives. These areas provide an entrance for decay-causing pathogens. Harvesting only when melons are dry can reduce abrasions caused by sand on the melon surface at harvest. Harvesting or loading wet melons is inadvisable because of the increased risk of decay. Watermelons are subject to impact damage and abrasion injury from rough surfaces during field harvesting and transport to loading areas. For this reason, field trucks or wagons should be well padded with burlap or carpet on the side, front and back walls (Figure 33). Six inches of hay or straw should be on the bottom. Padding on the bottom should be changed frequently to remove sand that causes abrasion injury to the rinds. Although it is common practice, workers should not ride on top of the load to packing facilities.

Figure 33. *Padding protects melons from damage as they are loaded and hauled from the truck.*

Direct sunlight can affect watermelon quality after harvest. Sunburn develops quickly on exposed melons whether on the ground or loaded in a truck. Temperatures above 90° F cause internal flesh breakdown and increase decay. These effects may require several days to become apparent. Shading is a necessary protection against direct sunlight and heat while waiting for bulk shipment or unloading at a packing facility.

Grading

Revised U.S. standards for watermelons (effective Jan. 15, 1978) have provided buyers measurable standards to distinguish between quality levels in market channels.

Grading is based on good and very good levels of optimum internal quality. The "good" sweetness level as measured with a hand refractometer requires not less than 8 percent soluble solids; "very good" levels are 10 percent or more soluble solids.

U.S. No. 1 watermelons shall be of similar varietal characteristics that are mature, but not overripe, and fairly well formed. They must be free from anthracnose, decay, sunscald and from damage caused by other diseases, sunburn, hail, scars, insects, hollow heart, whiteheart or mechanical injury.

Watermelons are graded by count based on a sample unit of 20 melons. Tolerances include 10 percent for total defects, 5 percent for badly misshapen and serious damage, and 1 percent for decay. A copy of these grade standards can be obtained through your county Extension office. Some buyers may require better quality than set forth in these standards for marketing.

Retail merchandising programs require watermelons to be packed according to specific weight sizes: small, less than 18 pounds; medium, 18 to 25 pounds; and large, greater than 25 pounds. Manual weight sizing is practiced at most packing sheds; however, computerized weighing systems can do this job mechanically. In addition to very accurate sizing, this procedure offers less physical handling, which reduces the chance of bruising injury.

More detailed information on USDA grades can be obtained from the USDA Agricultural Marketing Service or from the Internet at http://www.ams.usda.gov/standards.

Labeling

The inadequate product identification information currently found on shipping containers causes many problems in the distribution system. For this reason, it is mandatory that watermelon containers have the name (commodity), net weight, count and county of origin clearly printed on at least two external panels. Including the brand name and shipper is optional. Many packers use colorful graphically designed containers as a marketing tool for retail display.

Packing

Watermelons are loaded either as bulk shipments or packed into bins and cartons and loaded onto transport trucks. Bulk shipments are loaded adjacent to the watermelon-growing field. Typically, two to three members of the harvesting crew load the tractor-trailer with melons from the field truck. Bulk loading requires protection of melons from vibration and load shifting injury during transit (Figure 34). This is accomplished by placing a layer of straw in the floor of the trailer and between the melons and the front and side walls of the trailer. Sufficient straw is needed at the rear between the melons and rear doors to avoid damage caused by sudden stops. Often it is necessary to have a special bracing wall, constructed from a sheet of plywood and upright posts, positioned at the rear of a refrigerated trailer. Straw packed between the rear stack of melons and plywood sheet protects melons in transit. A minimum of five bales of straw is required to adequately protect a bulk load of watermelons. During bulk loading operations, watermelons are not physically protected by packaging. Therefore, workers must not sit, stand or walk over melons while loading because this will cause compression damage (Figure 35).

Packing watermelons in palletized bins and cartons is becoming more widespread because it offers unitized handling. Other advantages include:

- less labor with quicker unloading and handling of melons
- better use of trucks and dock space at terminal markets
- less melon damage because of the physical protection offered by packaging, which results in better quality.

Field-truck loads of watermelons are hauled to a centralized packing site where they are unloaded, graded, weight-sized and packed according to buyer specifications.

Shipping cartons (25 inches long by 20 inches wide by 9 inches high) hold three, four or five melons, depending on size; fiberboard bins (48 inches long by 40 inches wide by 36 inches high) hold on average 50 melons and are used for bulk shipments (1,150 pounds net weight). The immediate benefit of containers is less bruising because of less handling for individual melons. A minimum of five handlings is required between the field and retail display with the bulk packing system. The bin or carton packaging system can eliminate at least one of these steps. A recent USDA study compared the bulk system and the bin system. It showed that the elimination of only one handling step resulted in a 33 percent reduction in losses for watermelons handled in bins. Uneducated packers cause internal melon bruising during bin and carton packing. Dropping melons into bins produces impact shock and standing or sitting on loaded melons inside bins causes compression injury. All handlers should learn that the absence of rind injury does not justify rough handling because bruising occurs first to the internal flesh.

Figure 34. *Straw protects against vibration and impact damage during truck shipment.*

Figure 35. *Body weight causes bruising and splitting of watermelon flesh.*

Shipping

Bulk shipments of watermelons must be padded by sufficient straw to protect them from damage during transit.

In addition, trailers should be adequately vented. An enclosed trailer should have two vent doors on the front and two on the rear to allow air passage within the melon load. Otherwise, overheating of melons can result in increased decay and quality loss.

Minimize damage to bin- and carton-packed melons during shipment by doing the following:

- Use pallet sizes to match bin dimensions to prevent top-stacked bins from falling into bottom bins and damaging melons.
- Use pallets in good condition to avoid pieces breaking off during transit and damaging melons in lower bins.
- Be sure to set top pallets properly on bottom bins to avoid shifting during transit.
- Brace the rear of the load properly to prevent carton shifting and damage during transit.
- Avoid overfilling bins so that melons inside will not be damaged when bins are stacked on top.
- Secure the body of the top bin to the pallet on which it is sitting to prevent vibration during transit, which causes the bin to ride up and allowing melons to fall out the bottom.
- Make sure all bins, cartons and the trailer are adequately vented.

Storage

Temperature management is important for optimum watermelon quality. The optimum storage temperature for melons is 60° F. Transit temperatures of 55° to 70° F with ventilation are recommended. Whole watermelons should not be refrigerated.

At temperatures below 50° F, chilling injury can develop, causing decreased redness and juice leakage of the internal flesh, and surface pitting and Alternaria decay to the melon rind (Figure 36). Chilling will also cause discoloration in the internal flesh after the melon is warmed to room temperature if it was bruised before cold storage (Figure 37).

Once melons are sliced for sectional display, they should be wrapped with film and stored at 32° F to avoid souring.

Watermelons are normally shipped in open or closed trucks and trailers without refrigeration. Melons should not be shipped in closed trucks or stored with fruits (bananas, peaches) and vegetables (tomatoes, cantaloupe) that emit ethylene. Ethylene is a colorless gas regarded as the natural aging or ripening hormone. When exposed to ethylene, watermelons breakdown internally and the flesh takes on a water-soaked appearance. This leads to flesh softening and flavor loss.

In summary, the important factors in determining watermelon quality during harvesting and handling are:

- Harvest fruit at the maturity best suited for the intended market.
- Avoid injury during harvesting, handling, packing and shipping.
- Maintain proper storage temperature at 60° to 70° F.

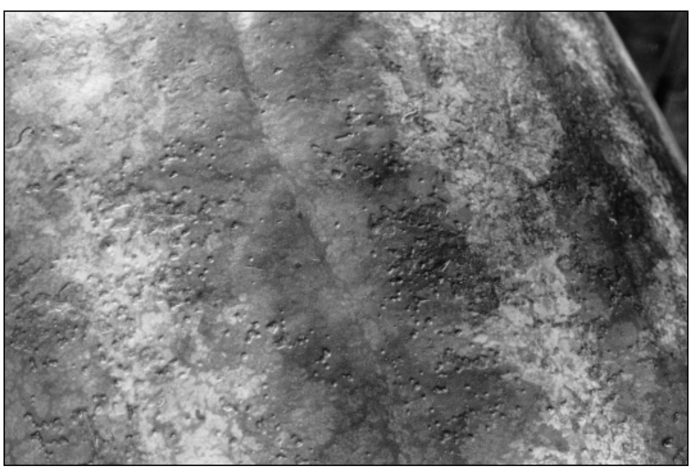

Figure 36. *Surface rind pitting occurs when melons are improperly stored.*

Figure 37. *Darkened flesh is a result of external bruising before storage.*

Production Costs

George O. Westberry, Extension Economist-Farm Management

Enterprise budgets may be used to estimate watermelon production costs and break-even prices. The cost estimates included in the budgets should be for inputs deemed necessary to achieve the specified yields over a period of years.

Production practices, operation size, yields and prices vary among farms, regions and times of the year. For these reasons, each grower should adapt budget estimates to reflect his or her particular situation. Below, budgets are estimated for two methods of production. Conventional (bareground) production is still the dominant method, but plasticulture is becoming more important. Detailed printed and electronic budgets are available in most county Extension offices.

Type of Costs

Total costs of producing any crop include both variable and fixed costs. The variable, or operating, costs change with the amount of crop produced. Common variable costs include seed, fertilizer, chemicals, fuel and labor. 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 and are often overlooked for planning purposes.

Variable costs are further broken down into preharvest and harvest operations in the budget. 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 is included as a variable cost in this budget. If land is double cropped, each enterprise should be charged half the annual rate. Ownership costs for a tractor and equipment (depreciation, interest, taxes, insurance and shelter) are included as a fixed cost per hour of use. Overhead and management are calculated by taking 15 percent of all preharvest variable expenses. This figure compensates for management and farm costs that cannot be allocated to one specific enterprise. Overhead items include utilities, pickup trucks, farm shop and equipment, and fees.

Table 3. Costs per Hundredweight, 1998

Cost	Bareground	Plastic
Preharvest cost	$1.86	$2.17
Harvest and marketing cost	$1.75	$1.75
Fixed cost	$0.62	$0.54
Total cost	$4.23	$4.46

For current cost estimates, see the most recent Extension vegetable budgets.

Cost per Unit of Production

Table 3 shows the cost per unit comparison of bareground to plastic mulch. In addition, cost per unit is at the bottom of the budgets (tables 4 and 6). The preharvest variable costs and the fixed costs decline fairly rapidly with increases in yield.

Budget Uses

In addition to estimating the total costs and break-even prices for producing watermelons, the budgets have other uses.

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 cost estimates by item can help accurately determine an equitable share arrangement by the landlord and tenant.

Risk Rated Net Returns

Because yields and prices vary so from year to year, the "riskiness" of producing watermelons has been estimated. 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 reaching 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 5) shows that with bareground production, a grower has an 80 percent chance of covering all costs. Half of the time, the budgeted grower would expect to net $553 or more. Half of the time, he would expect to net less than $553. One year out of six, he would expect to make more than $1,206 per acre or to lose more than $92.

The risk rated section of the plastic budget (Table 7) shows that a grower has a 76 percent chance of covering all costs. Half of the time, the budgeted grower would expect to net $983 or more. Half of the time, he would expect to net less than $683. One year out of six, he would expect to make more than $1,667 per acre or to lose more than $302.

Readers should recognize the examples shown here are estimates. They should serve as guides for developing their own estimates.

Table 4. Watermelon Prices, Costs and Revenue Estimates (Bareground)

	Best	Optimistic	Median	Pessimistic	Worst
Yield (cwt.)	500	400	250	125	0
Price per cwt.	8.25	7.25	6.25	5.25	4.25

ITEM	UNIT	QUANTITY	PRICE	DOLLARS PER ACRE
Variable costs				
Seed or plants	Lb.	2.00	30.00	60.00
Lime, applied	Ton	0.50	26.00	13.00
Fertilizer	Cwt.	10.00	8.50	85.00
Sidedressing	Acre	1.00	16.35	16.35
Insecticide	Application	1.00	6.85	6.85
Fungicide	Application	8.00	12.45	99.60
Nematicide	Acre	1.00	51.00	51.00
Herbicide	Acre	1.00	13.44	13.44
Machinery	Acre	1.00	18.76	18.76
Labor	Acre	1.00	15.75	15.75
Land rent	Acre	1.00	50.00	50.00
Irrigation	Application	3.00	4.26	12.78
Interest on operating capital	Dollar	442.53	10.5%	23.23
Total preharvest				**465.76**
Harvest and hauling	Cwt.	250	1.75	437.50
Total variable costs				**903.26**
Fixed costs				
Machinery and irrigation	Acre	1.00	86.07	86.07
Land	Acre	1.00	0	0
Overhead and management	Dollar	465.76	0.15	69.86
Total fixed costs				**155.93**
Total budgeted cost per acre				***1,059.19***
Costs per cwt.				
Preharvest variable cost per cwt.		1.86		
Harvest and marketing cost per cwt.		1.75		
Fixed costs per cwt.		0.62		
Total budgeted cost per cwt.		***4.23***		

Table 5. Watermelon Risk Rated Net Return (Bareground)
Net return levels (top row), the chances of obtaining this level or more (middle row) and chances of obtaining this level or less (bottom row)

	Optimistic		Expected			Pessimistic	
Returns ($)	1,533	1,206	880	553	231	-92	-414
Chances	7%	16%	31%	50%			
Chances				50%	31%	16%	7%

Overall chance of profit is 80%.
Expected value of net returns is $553.
Profit is return to risk and all "zero" items in the budget.

Table 6. Watermelon Prices, Costs and Revenue Estimates (Plastic)

	Best	Optimistic	Median	Pessimistic	Worst
Yield (cwt.)	800	600	400	200	0
Price per cwt.	8.25	7.25	6.25	5.25	4.25

ITEM	UNIT	QUANTITY	PRICE	DOLLARS PER ACRE
Variable costs				
Seed	1,000	1.50	30.00	45.00
Plants	1,000	1.50	47.00	70.50
Lime, applied	Ton	0.50	26.00	13.00
Fertilizer	Cwt.	10.00	8.50	85.00
Sidedressing	Acre	1.00	95.00	95.00
Insecticide	Application	1.00	6.85	6.85
Fungicide	Application	10.00	12.45	124.50
Nematicide	Acre	1.00	51.00	51.00
Herbicide	Acre	1.00	13.44	13.44
Plastic	Roll	2.80	65.00	182.00
Plastic Removal	Acre	1.00	28.00	28.00
Machinery	Acre	1.00	18.76	18.76
Labor	Acre	1.00	15.75	15.75
Land rent	Acre	1.00	50.00	50.00
Irrigation (sprinkler)	Application	6.00	4.26	25.56
Interest on operating capital	Dollar	824.36	10.5%	43.28
Total preharvest				**867.64**
Harvest and hauling	Cwt.	400	1.75	700.00
Total variable costs				***1,567.64***
Fixed costs				
Machinery	Acre	1.00	50.69	50.69
Irrigation	Acre	1.00	34.51	34.51
Land	Acre	1.00	0	0
Overhead and management	Dollar	867.64	0.15	130.15
Total fixed costs				**215.35**
Total budgeted cost per acre				***1,782.99***
Costs per cwt.				
Preharvest variable cost per cwt.		2.17		
Harvest and marketing cost per cwt.		1.75		
Fixed costs per cwt.		.54		
Total budgeted cost per cwt.		***4.46***		

Table 7. Watermelon Risk Rated Net Return (Plastic)

Net return levels (top row), the chances of obtaining this level or more (middle row) and chances of obtaining this level or less (bottom row)

	Optimistic		Expected			Pessimistic	
Returns ($)	2,160	1,667	1,175	683	190	-302	-795
Chances	7%	16%	31%	50%			
Chances				50%	31%	16%	7%

Overall chance of profit is 76%.
Expected value of net returns is $683.
Profit is return to risk and all "zero" items in the budget.

Seedless Watermelons

Production of seedless (triploid) watermelons is becoming more and more popular. Production cost is higher and requires an analysis to determine profitability. Primary differences are: seed cost, seedling vigor, market price, and the requirement that one-third of the rows be planted to a pollenizer (Table 8).

The comparison (Table 9) shows that when watermelons are produced on plastic, seedless melons should be more profitable. Expected returns from seedless are almost $200 per acre greater, and the chance for profit is 1 percent greater.

Bareground production shows a different picture. If it is assumed that seedless culture requires the use of transplants, returns are less and probability of profit is 5 percent less.

Thus, growers of melons on plastic may profit from seedless (triploid) production. Bareground producer should probably stick with seeded (diploid) melons.

Table 8. Comparison of Seedless to Seeded

Assumptions	Seeded	Seedless
Seed cost per 1,000	$30	$123.39*
Plant growing cost per 1,000	$47	$50.46*
Market price per lb.		+15%*

*Includes proportionate seeded

Table 9. Economic Comparison of Seeded vs. Seedless on Plastic and Bareground

	Bareground			Plastic	
	Seeded from Seed	Seeded from Plants	Seedless from Plants	Seeded	Seedless
Preharvest variable cost per cwt.	$1.86	$2.20	$2.81	$2.17	$2.56
Harvest and marketing cost per cwt.	$1.75	$1.75	$1.75	$1.75	$1.75
Fixed cost per cwt.	$0.62	$0.67	$0.77	$0.62	$0.68
Total cost per cwt.	$4.23	$4.62	$5.33	$4.54	$4.99
Chances for profit per acre	80%	76%	75%	76%	77%
Expected returns per acre	$553	$456	$521	$683	$880

Marketing

William O. Mizelle, Jr., Extension Economist

Consumers, not producers, drive the U. S. economy; therefore, marketing must be customer oriented. Marketing must provide:

- what the customers want
- when they want it
- where they want it
- how much they want to buy
- at a price they are willing to pay

What

Customers' wants are normally reflected in the variety and its characteristics. Size is important. Does the customer want a melon less than 20 pounds, between 20 and 30 pounds, or more than 30 pounds? Shape is important to some customers. Do they want a long melon or a round one? Next is color. Do they want stripes, light green or dark green external color? How about the internal color? Normally, a deep, dark red is preferred. Taste is the final characteristic of what the customer wants. Taste is difficult to anticipate, but most customers prefer a melon with a high sugar content and one that has a firm flesh.

When

Melons have historically been preferred during the summer picnic season. June and July are the primary months, accounting for 40 percent of the annual supplies (Figure 38). Georgia ships 90 percent of its production during these two months. August accounts for 17 percent of the total U.S. production and 9 percent of Georgia's. The popularity of salad and fruit bars is helping to increase sales during the nonpicnic seasons. Volume sales before June have increased to 23 percent in 1996 from 19 percent in 1986. Similar increases have occurred after August, with volume sales increasing to more than 20 percent in 1996 from 10 percent in 1986.

Where

The location of the population and their tastes and preferences determine the demand for melons. The top three markets are the three largest cities: New York, Los Angeles and Chicago. The next three largest markets are Atlanta, Baltimore-Washington and Detroit. The top markets for Georgia's melons are Atlanta, Chicago, Baltimore-Washington, Detroit and Cincinnati.

Georgia's sales are distributed mostly east of the Mississippi. The South receives nearly half of Georgia's shipments. The Midwest receives about one-fourth, and the remainder goes to the Northeast and Canada.

The primary competitors for Georgia in June are Florida and Texas (Figure 39). Georgia is the leading volume state in July. In July, 18 other states are also in production, with the Carolinas in the South and Missouri in the Midwest providing the heaviest competition (Figure 40).

How Much

Nationally, annual per capita consumption is about 17 pounds. Consumption was declining until the mid-1980s:

- 18 pounds in 1947-49
- 17 pounds in 1957-59
- 14 pounds in 1967-69
- 12 pounds in 1977-79
- 13.4 pounds in 1987-89
- 17.2 pounds in 1997-98

As mentioned earlier, the popularity of fruit bars has helped to extend the season and has helped to reverse the decline in consumption. Fruit bars are supplied by food service firms that prefer larger melons (30 to 40 pounds).

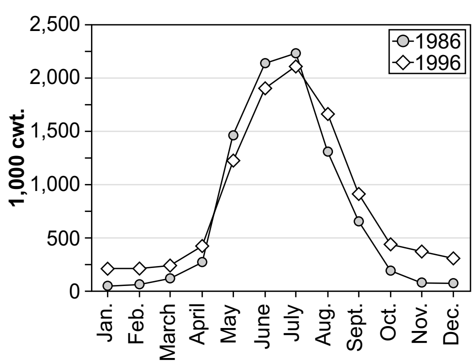

Figure 38. *Monthly watermelon volume (arrival in 22 major U.S. markets)*

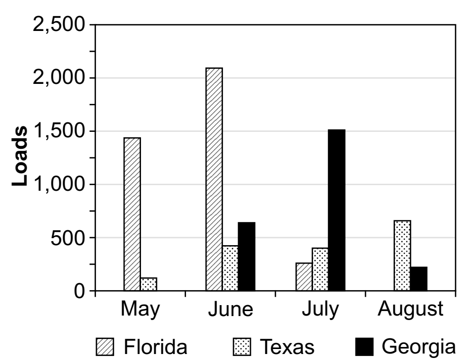

Figure 39. *Watermelon shipments*

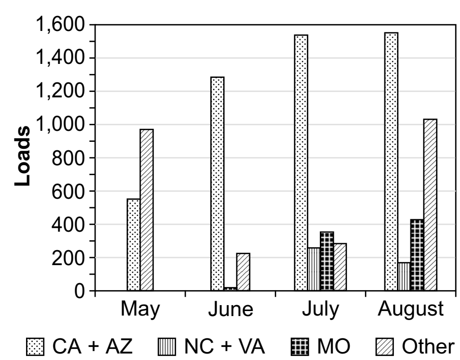

Figure 40. *Other states*

What Price

Watermelon prices are quite volatile. Late spring through early summer (1993-97) prices ranged from a low of $3.50 (f.o.b.) per hundredweight to a high of $14.50. Prices tend to decline throughout much of the season (Figure 41). Average season (late May to late July) prices for 20- to 24-pound melons range from around $5.75 to $9.00 per cwt. The USDA estimated season prices for all melons range from $3.60 to $6.60 per cwt. The 1998 Georgia budgets indicate production costs of $4.14 to $4.99 per cwt. For recent prices, see the Agricultural Economics Department's *Vegetable Economics—A Planning Guide.*

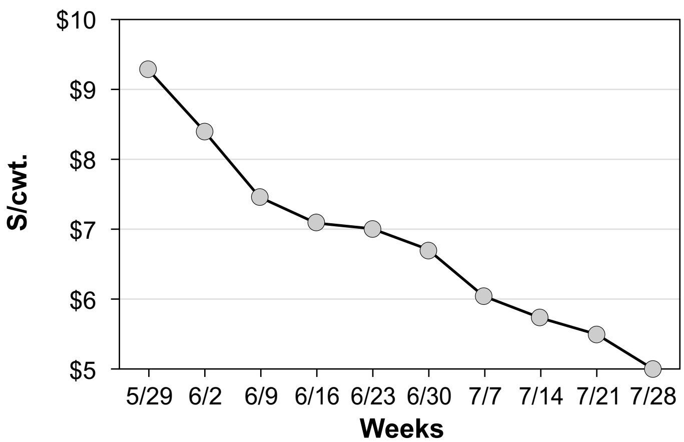

Figure 41. *Watermelon average prices, 1992-96. FOB prices per cwt., 20-24 lb. average*

Marketing Methods

There is no particular best method of marketing watermelons. Growers should determine which methods are available to them and use the marketing method that is expected to return the most income for their land, labor, management and time. The different marketing methods include:

- selling the field
- selling through the Cordele market
- retailing at farmers markets
- selling direct to truckers or stores
- selling through brokers or shippers

The field method of sales, whether by acre or by pound, is preferred by many growers because it is relatively simple. Basically, the grower finds a buyer willing to purchase the entire field. Often, the buyer does the harvesting.

Large watermelon growers (more than 20 acres) generally use brokers. Brokers or shippers are capable of handling the large volume sales that these growers require. Brokers provide the marketing services that individual growers are not able to provide. They have contacts in the major markets so that they can move large volumes of melons over an extended period of time. Their contacts with both producers and buyers allow for matching buyers' needs with what the producers have. The matches include volume, variety, size, transportation, etc.

Smaller growers use the Cordele market (less than 20 acres), by large growers as a convenient location to weigh loads on their way to market, and as a location for out-of-town brokers. More than half of the annual Georgia volume goes through this market. The grower is responsible for harvesting and hauling to the market. Melons sold through this market are exposed to more potential buyers than through field sales.

Farmers market retail sales should result in higher prices than other methods. The grower is responsible for the marketing functions of harvesting, transporting and selling. The amount of time required to sell a load through this method is so great that large acreage growers are not able to move enough melons this way.

Direct sales to truckers or to chains is a reasonable marketing method for the grower who has the contacts. The growers' volume must match their contacts' needs. Matching needs with volume is difficult, which often prevents this method from being used.

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