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Commercial Sweet Corn Production in Georgia

Compiled by the Vegetable Extension Team of the University of Georgia
Editor: Changying "Charlie" Li

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Culture and Varieties

George Boyhan, Extension Horticulturist - Vegetables

Sweet corn differs from field corn in the amount of sugar produced in the kernels. This is due to a mutation that allows sweet corn to develop more sugar in the kernel than field corn. If harvested late or improperly stored, sweet corn will eventually become starchy like field corn. Therefore, sweet corn is always harvested at a slightly immature stage, refrigerated or processed immediately by freezing or canning.

Sweet corn is wind pollinated. The ears are female and the tassels are male. When mature, the male flowers will shed large amounts of pollen that will be distributed by the wind. Pollen that lands on ear silks will grow down the silk and fertilize the female kernels. Bees may be seen in large numbers collecting pollen from sweet corn, but they have no role in pollination. Because sweet corn is wind pollinated, plantings should be in blocks with a minimum of five rows. This is usually not a problem in commercial plantings, but small growers should be aware that without sufficient pollination, kernels will not develop correctly.

Sweet corn is always direct seeded. Rows are spaced 30-42 inches apart with an in-row spacing of 6-12 inches. If the corn is to be mechanically harvested, growers should make sure the row spacing is appropriate for the harvesting equipment.

Sweet corn planting dates in south Georgia are from February 1 – March 31 for spring production and July 15 – August 31 for fall production. In north Georgia, planting dates range from April 1 – May 15 for spring/summer production. Fall planting is recommended from July 1 – July 31. Sweet corn can be produced during all of the warmer months so recommended planting dates are just that, recommendations. Sweet corn production requires sufficient time to mature before freezing temperatures arrive. Sweet corn can tolerate some cold temperatures and light frosts so very early sowing in south Georgia (February) is possible. If frosts are expected, thoroughly irrigate the field immediately preceding the event to improve the crop's tolerance for low temperatures.

An alternative method of planting involves using clear plastic mulch. This alternative method is suitable for very early planting when temperatures, particularly soil temperatures, are low. In this method sweet corn is sown in double rows, with 14 inches between rows and 6-12 inches in-row. These double rows are planted on 6-foot centers and then covered with clear plastic. The plastic remains in place for 30 days before it is removed. Preparing the field with trenches and seed sown at the bottom of these prior to covering with clear plastic allows the plants to grow without restriction under the plastic. In addition, holes may be punched in the plastic to allow water to enter the soil. This method should be used only on an experimental basis until you are comfortable with the results.

There are several basic types of sweet corn available based on specific genes. The oldest sweet corn varieties have the *su* gene, which is the primary mutation for developing sweetness. There are also varieties that have the *se* gene, which stands for 'sugary enhanced.' This gene enhances the sugar content of sweet corn and can extend shelf life by a couple of days. The third type of sweet corn has the sh_2 gene, which stands for 'shrunken 2.' This is a new type of sweet corn with two to three times the amount of sugar as the other types. In addition, conversion of sugar to starch is much slower. The sh_2 varieties are often referred to as 'supersweets.' There are also varieties that have all three genes, which are referred to as 'triple sweets.'

Isolation between sweet corn varieties can be important. Supersweet varieties must be isolated at least 300 ft. from other sweet corn types. This isolation can also be in time, with 12 days difference in planting dates. There is no requirement for isolation between *su* and *se* varieties. If supersweets are not isolated from other types, the 'super sweet' nature of the variety will not be evident. This is due to the fact that the consumed portion of sweet corn (i.e., endosperm) is the direct result of pollination, unlike other vegetables where the consumed tissue is maternal, as in tomatoes or watermelon.

Sweet corn is available in three basic color arrangements: yellow, white or bicolor. The bicolor types produce ears with both yellow and white kernels. Yellow sweet corn is by far the most popular, but there are markets for white and bicolor varieties. White sweet corn varieties must be isolated from yellow varieties, as with supersweet varieties, in order to maintain the white color. If white sweet corn is planted in proximity to yellow varieties, they will have bicolor ears. Bicolor varieties planted in proximity to yellow corn will have a greater percentage of yellow kernels then they otherwise would.

There are a few sweet corn varieties that are genetically modified organisms (GMOs). These varieties are different because they have had a gene inserted directly into their DNA. The inserted gene, called the *Bt* gene, imparts resistance to a wide range of caterpillars. Because each plant expresses resistance to these caterpillars there is a greater chance of resistance developing to this gene in caterpillars, and resistance management should be practiced. This involves planting a percentage of susceptible plants to reduce the chance of resistance developing among the target caterpillar population. Usually 20 percent of a grower's sweet corn acreage should be planted with susceptible varieties. This planting is often referred to as a structured refuge. Growers should consult with their seed supplier for specific recommendations about resistance management for the varieties they grow. GMO sweet corn varieties remain controversial in the market and growers should talk to their buyers before growing these varieties. The resistance is generally very good, but buyers may be reluctant to handle these varieties because of the controversy surrounding them.

Along with degree of sweetness (i.e., *su*, *se*, or sh_2), kernel color and insect resistance, sweet corn varieties are divided into different maturity classes. There are three broad variety classes: early, mid-season and late season. These categories range from 60-95 days from sowing to maturity. Table 1 lists varieties recommended for Georgia. There are a large additional selection of varieties available, which growers may wish to try. Small initial plantings should be made to determine how they will perform before investing in large acreages.

The corn silk will be dry and brown and the ears will have a slightly wider crotch angle when the crop is mature. Sweet corn will be ready for harvest at the 'milk' stage. Harvest several ears and press your thumbnail into the kernels. There should be a milky liquid, which indicates the crop is ready for harvest. Sweet corn should be harvested as quickly as possible once it reaches maturity and field heat removed (see section on postharvest handling). The sugar in sweet corn can quickly convert to starch, rendering the ears unmarketable. This is particularly true with *su* and *se* varieties.

Table 1. Sweet corn varieties recommended for Georgia based on the Southeast Vegetable Crop Handbook.

Variety	Characteristics
Early	
Sweet Ice	*se*, white
Bodacious	*se*, yellow
Seneca Horizon	*su*, yellow
Sweet Riser	*se*, yellow
Mid-season	
Argent	*se*, white
Ice Queen	sh_2, white
Silverado	*se*, white
Snowbelle	*se*, white
Summer Sweet 8101R	sh_2, white
WH 0809	sh_2, white
Xtra-Tender 375 A	sh_2, white
Xtra-Tender 377 A	sh_2, white
Xtra-Tender 378 A	sh_2, white
Bandit	sh_2, yellow
Crisp N' Sweet 711	sh_2, yellow
GH 0851	*se*, yellow
GSS 0966	sh_2, yellow
Honey Select	*se*, yellow
Merit	*su*, yellow
Passion	sh_2, yellow
BC 0805	sh_2, bicolor
Big Time	sh_2, bicolor
BSS 0977	sh_2, bicolor
BSS 0982	sh_2, bicolor
Obsession	sh_2, bicolor
Summer Sweet 8102	sh_2, bicolor
Sweet Chorus	sh_2, bicolor
Sweet Rhythm	sh_2, bicolor
Sweet Symphony	*se*, bicolor
1283 Xtra Tender	*se*, yellow
Sweet Talk	*se*, yellow
Saturn	*se*, yellow
Devotion	*se*, yellow
Late	
Even Sweeter	sh_2, white
Pegasus	sh_2, white
Silver Queen	*su*, white
Tahoe	sh_2, white
WSS 0987	sh_2, white

Soils and Fertility

George Boyhan, Extension Horticulturist - Vegetables

Sweet corn does best in well-drained fertile soils. It can be grown under less than ideal soil conditions with proper management. This section will help you manage your soil and optimize sweet corn production. The site selected for production should not have been planted with corn or cucurbits (e.g., watermelon, cantaloupe, etc.) in the previous year. Crop rotation across plant families can help minimize soilborne diseases and improve soil fertility. Growers should give serious consideration to a multi-year crop rotation plan; local county Extension agents can help with this.

The first step in successful sweet corn production is to collect a soil sample for testing. It is best to take this soil sample two to three months prior to planting. A test will give you an assessment of your soil's condition and the necessary management options required. For a soil test to be meaningful the soil must be collected in a manner that fairly represents your field. Areas of a field with different soil texture or type, slope or location should be sampled separately. Your local county Extension agent can supply soil test bags and help collect samples.

Soils in Georgia are split into two broad categories: The Coastal Plain soils of south Georgia and the Piedmont, Mountain and Limestone Valley soils of north Georgia. Coastal Plain soils are lighter sandy loam soils that generally drain quickly and warm early in spring. They are characterized as unstructured mineral soils with very little organic matter. This means they do not hold together to form clods and are relatively infertile as cultivated soils. With proper management and fertilization, however, they can be very productive. Because they warm early and drain well they are ideal for vegetable production.

Soils of north Georgia tend to be heavier and have a greater amount of clay content. The famous "red clay" of Georgia belongs in this group (the red color comes from iron oxides in the soil). These soils are generally more fertile than soils in the Coastal Plain because of the higher clay content; consequently, nitrogen recommendations are lower for these soils. A soil test takes into account the differences between these soil types when recommendations are made.

Soil testing two to three months prior to planting gives you time to correct any soil pH problem. Generally, soils in Georgia are acidic and low soil pH is very common. The ideal soil pH for sweet corn production is 6.0-6.5. The soil test will give recommendations to adjust the soil pH if it is too low or too high. Generally, either calcitic or dolomitic lime is used to raise soil pH. Calcitic lime will also supply calcium, while dolomitic lime will supply both calcium and magnesium. Lime should be incorporated 6-8 inches deep so soil pH can be adjusted throughout the root zone.

In general, for vegetable production, including sweet corn production, it is recommended to deep turn previous crop residue at least a month in advance of planting to ensure complete breakdown of this material. Deep turning may not be necessary if crop residues are light, there is no history of previous soilborne diseases and a smooth seedbed can be established for accurately sowing sweet corn seed. Soils should be prepared so there is no hardpan and there is a smooth, clod-free surface for sowing. If a hardpan is present the land should be chisel plowed or a subsoiler should be run across the field.

It may be possible to plant sweet corn as a no-till or limited-till crop. In a no-till or limited-till system, the land is not plowed or is plowed infrequently. In such a case, the previous crop or cover is killed with a general-purpose herbicide such as glyphosate prior to planting the sweet corn. Specialized planting equipment, which is capable of sowing seed in the previous crop residue, is required. Generally this type of equipment is larger and more expensive. The advantage of no-till or limited-till production is the reduction of soil erosion and the improvement in soil fertility.

Sweet corn is a heavy feeder and requires a substantial amount of nitrogen to be produced successfully. On the Piedmont, Mountain and Limestone Valley soils, 150-200 pounds of nitrogen per acre are recommended, while on the Coastal Plain soils, 200-250 pounds of nitrogen per acre are recommended. Some growers may need to use more nitrogen if the site is particularly sandy or has been heavily leached due to rain or irrigation. Nitrogen application should be split into two or three applications, with the first application at or just before planting. The first fertilizer application can be applied with the final soil preparation or banded at time of planting.

Phosphorus and potassium applications should follow soil test recommendations (Table 1). All the phosphorus should be applied at the time of planting. It is particularly important to apply phosphorus with early sown sweet corn as cool soil temperatures can make phosphorus relatively unavailable. Phosphorus deficiency will appear as a reddish or purplish color in developing leaves. Potassium recommendations should be split-applied and can be applied at the same time as nitrogen.

In addition to the primary nutrients nitrogen, phosphorus and potassium, other nutrients may be required for successful sweet corn production. If magnesium levels are low (< 60 pounds per acre) and lime is recommended, then dolomitic lime should be used. If magnesium is low and lime is not recommended, then 25 pounds per acre of magnesium should be applied. Commonly available sources of magnesium include magnesium sulfate (Epsom salts) and potassium magnesium sulfate (Sul-Po-Mag). The former also supplies sulfur and the latter includes both sulfur and potassium.

Zinc may be required on Coastal Plain soils; however, it is never recommended on the Piedmont, Mountain or Limestone Valley soils. If zinc levels test low, then 5 pounds per acre of zinc is recommended. Sources of zinc include zinc sulfate and zinc chelate.

Sweet corn can be prone to sulfur deficiency, particularly on the Coastal Plain soils. In Georgia it is recommended that 10-20 pounds per acre of sulfur be applied with the first fertilizer application. Sulfur deficiency may be apparent early and then dissipate as roots grow deeper in the soil. Along with the materials listed above, calcium sulfate, also called gypsum or land plaster, is a commonly available material that can supply sulfur.

Finally, 1 pound per acre of boron is recommended but should not be exceeded as boron can easily become toxic. A common source of boron is borax. Boron should be applied with the last land preparation step.

If nutrient deficiency is suspected, tissue samples can be collected and analyzed. Table 2 lists the sufficiency ranges for nutrients in sweet corn. In addition, several rapid nitrate meters are available such as the Cardy nitrate meter and SPAD 502 chlorophyll meter. Both are available from Spectrum Technologies (1-800-248-8873; www.specmeters.com).

Table 1. Recommended potassium and phosphorous applications based on soil test ratings of each nutrient.*

Phosphorous Rating	Potassium			
	Low	Medium	High	Very High
	(Pounds N-P_2O_5-K_2O per acre)			
Low	-120-120	-120-90	-120-60	-120-30
Medium	-90-120	-90-90	-90-60	-90-30
High	-60-120	-60-90	-60-60	-60-30
Very High	-45-120	-45-90	-45-60	-45-30
*Nitrogen recommendations: Coastal Plain Soils: 200-250 lb./acre N. Piedmont, Mountain and Limestone Valley Soils: 150-200 lb./acre N.				

Table 2. Plant tissue analysis critical values for sweet corn with most recently mature leaf at 30 inches height.*

	Percent						ppm					
Nutrient	**N**	**P**	**K**	**Ca**	**Mg**	**S**	**Fe**	**Mn**	**Zn**	**B**	**Cu**	**Mo**
Deficient (<)	2.5	0.20	2.5	0.5	0.20	0.2	40	40	25	10	4	0.1
Adequate	2.5-4.0	0.20-0.40	2.5-4.0	0.5-0.8	0.20-0.40	0.2-0.4	40-100	40-100	25-40	10-30	4-10	0.1-0.2
High (≥)	4.1	0.41	3.1	0.81	0.41	0.41	101	101	41	31	11	0.21
Toxic (>)										100		
*Adapted from Knott's Handbook for Vegetable Growers, 5th Edition.												

Pesticide Application Equipment

Paul E. Sumner, Extension Engineer– Retired

Pesticides can be delivered by ground and aerial equipment. Ground equipment normally has a hydraulic boom arrangement consisting of the conduit that carries the spray liquid to the nozzles. The booms extend across a given width to cover a particular swath as the sprayer passes over the field.

Aerial application uses a hydraulic boom attached to the underside of an airplane or helicopter. Aerial application of pesticides offers the advantages of timely site treatment, pesticide treatment of crop sites not readily accessible to ground equipment (for example, wet fields), lower fuel energy costs per treated acre on large tracts and the ability to quickly cover a large acreage.

Most materials applied by a sprayer are a mixture or suspension. Uniform application demands a uniform tank mix. Most boom sprayers have a tank agitator to maintain uniform mixture. The agitation (mixing) may be produced by jet agitators, volume boosters (sometimes referred to as hydraulic agitators) and mechanical agitators. These can be purchased separately and put on sprayers. Make sure an agitator is on every sprayer. Some growers make a mistake of not operating the agitator when moving from field to field or when stopping for a few minutes. Always agitate continuously when using pesticides that tend to settle out.

Herbicides

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

Insecticides and Fungicides

Harvest losses due to corn earworms can be significant for late-planted corn. Sweet corn that silks and develops late in season can suffer considerable damage from earworms. During this period, it is important to protect the ears by applying insecticides every other day during the time from silking until harvest. Insecticides applied after the larva enters the ear are not effective.

Spray coverage

Spray solution should be driven deep into the silks to be of maximum benefit. The center third of the plant is the only zone that needs to be protected.

Ground spray equipment for commercial acreage is a high-clearance sprayer with four hollow-cone nozzles per row covering the ear zone (Figure 1). Experience with fungicide application in field corn has shown that a spray droplet size requirement in the upper fine to lower medium range (225 to 300 microns – Volume Median Diameter, VMD) was adequate for good coverage of the silks and ears. For ground application growers should apply 25 to 50 gallons per acre of finished formulation at 100 to 200 psi to achieve the desired spray droplet ranges. Aerial applications are effective at 2 to 5 gpa utilizing the same spray droplet range. When severe insect pressures occur, spraying intervals may need to be shortened.

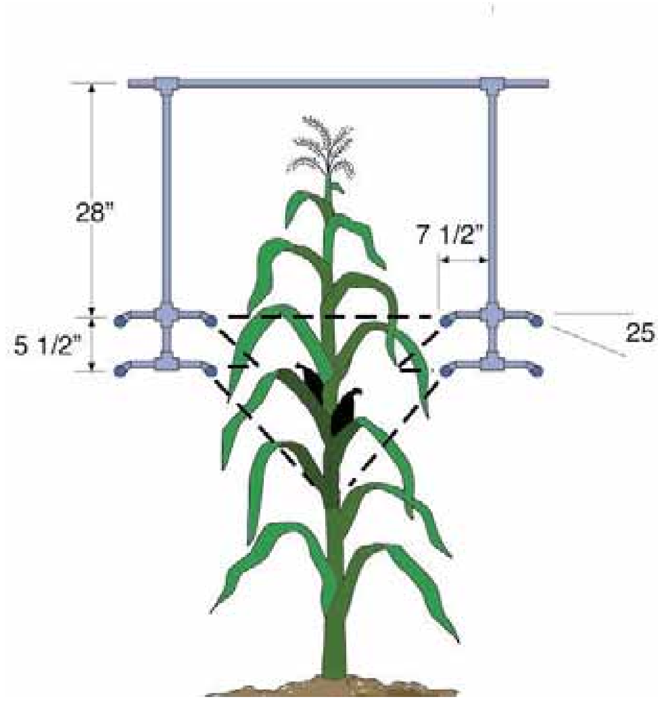

Figure 1. Boom setup for ground application of insecticide and fungicide on sweet corn

Calibration

Calibrate sprayers often. Calibration should be conducted every eight to 10 hours of operation to ensure proper pesticide application. A good calibration procedure to follow is explained in *Calibration Method for Hydraulic Boom and Band Sprayers and Other Liquid Applicators*, University of Georgia Cooperative Extension Circular 683.

Diseases

David B. Langston, Jr. - Extension Plant Pathologist

Diseases of sweet corn can cause severe losses by reducing yield and quality of marketable ears. The most important diseases in Georgia are fungal diseases that generally occur on the foliage prior to and during ear-fill. Most of the sweet corn is scouted for diseases and insects, and fungicide applications are made preventively or at disease onset. The four main diseases of sweet corn in Georgia (Northern and Southern Corn leaf blights and Southern and Common rusts) will be covered in this section.

Northern Corn Leaf Blight

Northern corn leaf blight (NCLB) is caused by the fungus *Exserohilum turcicum*. This fungal disease is favored by moderate temperatures (65-77° F) and high relative humidity and heavy dew events. It attacks the foliage and can only rarely directly attack the ears.

Symptoms: The disease is usually observed in the spring crop. Lesions associated with this disease are oblong and generally cigar-shaped (Figure 1.). They appear grayish-brown and may or may not contain concentric ring patterns within the lesions. These lesions begin on lower leaves and progress to newer leaves higher on the plant. Early infections and high disease pressure during silking can cause severe losses if left unchecked, especially under conditions favorable for disease development.

Management Options: Eliminate weed hosts such as johnsongrass and sudangrass. Plant resistant varieties. Strobilurin- and sterol-inhibiting fungicides are very effective if applied before disease onset.

Southern Corn Leaf Blight

Southern corn leaf blight (SCLB) is caused by the fungus *Bipolaris maydis*. SCLB is favored by higher temperatures than NCLB (68-90° F) but only needs damp condtions in which to sporulate and spread. It primarily attacks the foliage but can be found on stalks, ears and cobs.

Symptoms: This disease is usually observed in the summer or early fall. Symptoms on foliage appear as elongated, yellow to tan lesions that tend to be vein-restricted (Figure 2). These lesions may be bordered by yellowish-green or yellow halos. Damage can be severe on young plants.

Management Options: Deep turn soil to bury infected plant debris. Use disease-free seed. Plant resistant varieties. Like NCLB, SCLB may be controlled using strobilurins and sterol inhibitors.

Common Rust

Common rust is the most frequently observed fungal disease on Georgia sweet corn. The pathogen that causes common rust is *Puccinia sorghi*. It is a disease of cooler, humid weather experienced in the spring and can be made more severe by high nitrogen fertilization. Frequent heavy rains may hinder the spread of this disease.

Symptoms: Oval, reddish-orange pustules develop on both leaf surfaces soon after silking. The spores are dusty-red in appearance once pustules rupture, then turn black with age later in the season. The black spores infect the alternate host, Wood Sorrel (*Oxalis*), which, in turn, serves as the inoculum source for the next season of sweet corn.

Management Options: Reducing the alternate host can reduce initial, seasonal inoculum, but is difficult as this weed is encountered over a wide range of habitats. White corn varieties are generally more susceptible than yellow varieties; however, some varieties of yellow corn are very susceptible as well. Most fungicides provide good suppression, but sterol inhibitors and strobilurins are generally best.

Southern Rust

Southern rust, caused by the fungus *Puccinia polysora*, is similar to common rust in sweet corn but can be more damaging. It is favored by warm temperatures (80°F) and periods of high relative humidity, which makes it more prevalent in the summer and early fall.

Symptoms: Compared to common rust, southern rust pustules are a lighter orange color, smaller, more circular and rupture only on the upper leaf surface. Leaves, stalks and ear husks may become infected. The southern rust fungus overwinters as spores on infected corn debris from diseased plants.

Management Options: Rotation and deep-turning infested debris will serve to reduce inoculum from year to year. There are several hybrids that have good resistance to southern rust. Preventive applications of sterol inhibitor and strobilurin fungicides are recommended to suppress this disease.

Figure 1. Typical dark, cigar-shaped lesions associated with northern corn leaf blight. Photo courtesy of Dr. Richard Raid, University of Florida

Figure 2. Elongated, vein-restricted lesions associated with southern corn leaf blight infection. Photo courtesy of Dr. Richard Raid, University of Florida

Figure 3. Reddish-orange, rust-colored pustules of common rust may be observed on both upper and lower leaf surfaces. Photo courtesy of Dr. Richard Raid, University of Florida

Figure 4. Orange, circular pustules of southern rust may be observed on only the upper leaf surface. Photo courtesy of Dr. Bob Kemerait, University of Georgia

Insect Management

Alton N. Sparks, Jr., Extension Entomologist

Sweet corn can experience insect damage throughout the growing season, from soil insects feeding on seeds and seedlings through caterpillars feeding on ears at harvest. Pest pressure and damage severity varies greatly with production season and growth stage. Insect damage is of greater concern when ears, which are the marketable product, are present. Pest pressure is more severe in late spring through fall. While damage by a wide variety of pests is possible throughout the season, the key pests of sweet corn are caterpillars, which damage ears during spring production and also damage seedlings, whorl stage corn and ears in the fall.

The two primary pests of sweet corn in Georgia are the corn earworm and the fall armyworm. In spring production, these two pests pose the greatest threat near harvest, as they can build large populations and feed directly on ears. They are a threat in fall production from crop emergence through harvest as they feed in the whorl of developing corn, on tassels and on ears. Insecticides applied for these two pests generally control most other insects, particularly from silk emergence to harvest, when insecticides targeting these pests can be applied daily. Spring production typically escapes most insect damage prior to silking, and broad spectrum insecticides applied during ear formation for the primary caterpillar pests control other potential pests. One occasional exception to this is stink bugs, which may damage seedling corn at any time of year; however, this is not common. Research with transgenic sweet corn varieties that provide control of caterpillar pests have revealed emergence of additional pests, such as sap beeltes, when use of broad spectrum insecticides are eliminated. Fall production is under more severe pest pressure. Both fall armyworm and corn earworm can damage the fall crop during the whorl stage and again as ears are formed and filled. Lesser cornstalk borers are also of much greater concern in establishment of a plant stand in the fall crop. Ears of Bt sweet corn grown in the fall without broad spectrum insecticides are also attacked by a broader pest spectrum of pests than the spring crop.

Key pests

While multiple insect pests can occur in sweet corn production in Georgia, the corn earworm and fall armyworm require the greatest attention and insecticide use. Other pests that may trigger management decisions under typical production practices include stink bugs, lesser cornstalk borer and European corn borer.

Corn earworm, *Helicoverpa zea*

Larvae of the corn earworm (CEW) can damage corn in the whorl stage (Figure 1) but are a much greater threat as they feed down silk channels and damage the tips of ears, rendering the ear unmarketable in the fresh market. The adult moth has a wing span of about 1 ½ inches (Figure 2). Moths are tan to grayish-brown in color, with a dark spot in the center of each front wing. The hind wings are lighter with a wide dark band near the margins. The moths can often be found in the whorl of pre-tassel corn during the day and are active at night. The moths are attracted to fresh silks and eggs are preferentially laid on these silks. The white to yellowish spherical eggs are laid singly, although multiple eggs can be found on a single plant or silk mass. A ring of pink to black develops on the egg as the larva develops inside. Larvae can develop on pre-silking corn and can damage plants in the whorl stage, but they are a much greater threat during silking and ear fill. Eggs laid on silks hatch and the young larvae feed down the silk channel to the tip of the ear. Larvae feed on the silks and developing kernels and can fill the tip of the ear with moist frass. This damage may go undetected until harvest. Newly emerged larvae are clear to whitish with a dark head capsule. Larger larvae vary greatly in color from yellow to green to pink to dark brown (Figures 3, 4, 5). Larvae are covered with small bumps with spines, which give them a rough appearance that distinguishes them from fall armyworm larvae, which appear smooth. Corn earworm overwinters in Georgia and can occur during any growing season but generally presents the greatest pest potential in the late-spring and fall crops. Larvae that hatch and enter the silk channel are protected from insecticides and must be controlled prior to entering this protective site. Thus, frequent insecticide applications, often daily, are required to protect sweet corn from damage when CEW populations are high. It is not uncommon for untreated sweet corn in late spring and fall to experience near 100 percent infestation of ears.

Fall Armyworm, *Spodoptera frugiperda*

Fall armyworm (FAW) larvae can damage sweet corn at any stage. They are a serious threat in fall production of sweet corn as they can damage the crop from emergence to harvest. The adult moths are light brown to ash gray with a 1 ½-inch wing span (Figure 6). The forewings are mottled with dark and light spots and lines. The hind wings are light colored with a thin dark band at the margin. Eggs are laid in masses of 50 to several hundred and are covered with fuzzy scales from the female moth. Young larvae feed in groups but disperse as they grow larger. Full-grown larvae are about 1 ½ inches long. Large larvae vary in color from light tan or greenish to nearly black (Figures 7, 8, 9). A longitudinal, light colored stripe runs along each side of the body and a yellowish-gray stripe runs down the back. As with all armyworm larvae, the head is marked with a pale inverted 'Y.' The 'shield' immediately behind the head is marked with three longitudinal light lines. FAW larvae also lack spines on their skin, thus giving them a smooth appearance. FAW do not overwinter in Georgia, migrating up from Florida each year. They generally do not appear in south Georgia until mid-June; thus, the spring crop frequently escapes severe pressure from this pest. However, the fall crop can be decimated by this pest from planting through harvest. FAW will attack corn ears but is more common as a whorl stage pest. It is not uncommon for untreated sweet corn to experience near 100 percent whorl damage in fall plantings. Unlike the CEW, which typically enters corn ears through the silk channel, FAW chews entry holes into the ear anywhere along its length as well as through the silk channel. Damage to the ear is similar to that of the CEW but can occur anywhere on the ear (Figure 10), rendering the ear unmarketable in the fresh market. FAW control requires frequent insecticide applications. Unfortunately, CEW and FAW frequently require the use of different insecticides, as the FAW is resistant to pyrethroid insecticides, which tend to be the products of choice for CEW.

Other potential key pests

Lesser cornstalk borer, *Elasmopalpus lignosellus*

Larvae of lesser cornstalk borer (LCB) bore into plants just below the soil surface, weakening established plants and killing young seedlings. The larva is dark-colored with purple bands around its body (Figure 11). The larvae spin a silken tube that is attached at or near the site of entry into the plant. Fully grown larvae are about ¾-inch long and flip about vigorously when disturbed. This pest can cause severe stand loss when conditions are favorable to the insect. Outbreaks of LCB occur in hot, dry weather, typically in well-drained soil. These conditions generally occur in the fall. Because the insect is below the soil surface and is generally inside the plant or inside its silken tube, it is well protected from foliar applications of contact insecticides. When this pest is expected to present a problem, it is usually controlled with preventive applications of insecticide before or at planting.

Stink bugs (primarily southern green, *Nezara viridula*, and brown stink bug, *Euschistus* sp.)

Stink bug adults are shield-shaped insects about ¾-inch long with piercing, sucking mouthparts. Common species in sweet corn are either a uniform lime-green (southern green stink bug, Figure 12) or mottled brown with a cream to yellow underside (brown stink bug, Figure 13, and related species). A species of predatory stink bug that closely resembles the brown stink bug may be found in corn, but it has sharply pointed "shoulders" and much thicker mouth segments than plant-feeding stink bugs. Stink bug nymphs vary in color based on species and age but are much more round than adults. The barrel-shaped eggs are laid on end in masses. Nymphs remain in groups in the early instars and disperse as they grow. Stink bugs can injure corn throughout its growth. Damage severity depends on the tissue injured and plant development. Heavy feeding on corn seedlings can result in severe plant deformity or plant death. Feeding in the whorl stage causes relatively minor injury. Feeding on ears early in development causes ear deformities, while feeding near harvest impacts individual kernels. Stink bugs are typically controlled during ear development by broad spectrum insecticides applied for corn earworm control. Stink bugs can require specific control measures in pre-tassel corn. In fall corn, they are typically controlled by broad spectrum insecticides applied for fall armyworm and corn earworm. As control of these caterpillar pests shifts toward caterpillar-specific insecticides, the potential emergence of stink bugs as a pest should be monitored. The potential establishment of the Brown Marmorated stink bug in Georgia may also change the pest status of this pest complex, as this species has shown the potential to reach damaging populations much more consistently.

European Corn Borer, *Ostrinia nubilalis*

The European corn borer (ECB) is a primary pest of sweet corn in northern states. While this species does occur in Georgia, it is generally more of a regulatory pest than an economic pest. ECB does present a potential for damage but is commonly controlled with insecticide applications targeted at FAW and CEW. Shipping sweet corn to some states does require trapping, preventive applications of insecticides and a phytosanitation permit. For details on the states involved and the specific requirements, contact the Georgia Department of Agriculture before planting.

The ECB lays egg masses of up to 50 eggs that resemble overlapping fish scales. They are not covered with scales, which distinguishes them from armyworm egg masses. The eggs do turn dark as they near hatching. Fully-grown larvae are about ¾ to 1 inch in length. They vary in color from light pink or tan to gray, with conspicuous small, dark spots on each segment (Figure 14). Larvae are often described as appearing greasy, and they can feed and develop on any stage of corn. Whorl feeding often results in characteristic 'shot-hole' damage. The larva bores through the rolled leaf and as the leaf grows and unrolls a line of holes appears across the leaf. Larvae will also bore into the stalk and tassels, which can result in lodging or breakage. Larvae can bore into ears from the base, through the sides or enter through the silk channel.

Occasional or secondary pests

Soil and seedling insects

A variety of insects can attack sweet corn seeds and seedlings; however, most do not require treatment in the spring crop. Soil insects such as wireworm, white grub, seedcorn maggot (*Delia platura*) and rootworm larvae (*Diabrotica* sp.) are potential seedling pests but are not consistent in Georgia. Many of these pests tend to provide greater problems in weedy fields previously fallowed or fields previously in turf. Where potential problems exist, preventive insecticide treatments (seed treatments, pre-plant or at-planting) are recommended. Because these pests are typically below the soil surface, treatments after infestation generally yield poor results.

Cutworms are grouped here with soil insects but can be controlled with foliar applications. Larvae are cryptically colored and can be very difficult to find (Figure 15). They are active at night and are most easily found at twilight and dusk. Larvae cut plants off at or near the soil line and can cause severe stand loss (although this is fairly rare). Larvae curl up when disturbed. Because they do move about on the soil surface, foliar insecticide applications can be effective. It is generally recommended to spray late in the day to ensure maximum exposure as the larvae emerge that evening.

Aphids (Corn leaf aphid, *Rhopalosiphum maidis*, and others)

Multiple species of aphids can be pests of corn; however, none present consistent problems in Georgia. Aphids (Figure 16) have piercing-sucking mouthparts, feed on plant sap, can transmit diseases and produce honeydew. Heavy populations on tassels can interfere with proper pollination of ears. Insects present in the husks, or sooty mold growing on honeydew on the husks, can hurt grades. This seldom occurs in Georgia and scouting should detect populations well before they reach damaging levels. In addition, insecticides currently used for caterpillar control suppress aphid populations.

Twospotted spider mites, *Tetranychus urticae*

Spider mites (Figure 17) are not a common pest of sweet corn in Georgia, but appear to be emerging as a potential threat. This pest has become more consistent on other vegetables and has presented concerns for sweet corn growers in recent years. Spider mites occur on the undersides of leaves. Large populations can cause leaves to wither and die. Until recently, the only true acaricide registered for use on sweet corn required use early in population development for greatest efficacy, thus compounding concerns with this pest. Recent registration of a more curative type of acaricide allows producers to monitor this pest and treat only as populations begin damaging the crop (some leaf damage can be tolerated with minimal impact on yield).

Sap beetle, *Carpophilus* sp. and *Glischrochilus quadrisignatus*
Sap beetles are small brown to black beetles (*G. quadrisignatus* does have four prominent white spots on the elytra) that are primarily scavenging insects that feed on overripe or damaged fruits and vegetables and other decaying organic matter. In sweet corn, they are likely attracted to ears damaged by caterpillars but will also infest undamaged ears. Adults feed directly on kernels and also lay eggs on the silks. Larvae hatch and feed on silks and kernels. Damage by adults or larvae render the ear unmarketable (Figure 18). Larvae appear somewhat similar to fly larvae but will possess a light brown head on one end and a light brown dorsal plate at the opposite end of the body. In commercial fields, these pests are controlled by broad spectrum insecticides targeted at CEW. Reduced insecticide use associated with transgenic sweet corn can allow these beetles to become a primary pest, thus preventing insecticide-free production. However, insecticidal control of sap beetles does not require the frequency of application currently needed for caterpillar pests. If caterpillar control in commercial production shifts to more selective insecticide use, these pests may require additional controls.

Silk flies, three *Euxesta* sp. and one *Chaetopsis* sp.
Silk flies are small picturewing flies that have emerged as a pest of sweet corn in Florida. They do occur in Georgia but have not presented problems yet. While the adults can be found in both spring and fall crops, research in non-insecticide-treated plots suggests these pests are of potential concern primarily in the fall crop. Larvae in the ears can cause severe damage (Figure 17). The larvae are whitish and elongated with mouth hooks visible through the body at the head and two small dark spiracles at the rear. Broad spectrum insecticides targeted at CEW and FAW currently appear to provide control of this pest complex in Georgia. Heavy damage has occurred in research plots where transgenic sweet corns have been grown without insecticide inputs. Similar concerns may arise if insecticide use shifts to highly selective insecticides for caterpillar pests.

Crop Characteristics and Management Effects on Insects

As previously discussed, research with transgenic (Bt) sweet corns has revealed potential emergence of several pests with the elimination of broad spectrum insecticide use against caterpillar pests. Pests of greatest concern have been the sap beetles. Silk flies are of concern in the fall crop, and stink bugs can occur throughout the year but have been less consistent. While these data have been generated in the absence of insecticides, similar emergence of pests could occur with a shift to use of highly selective insecticides targeting caterpillar pests. Most of these insecticides have minimal impact on the emerging pests.

Finally, plant characteristics can impact pest severity. Varieties with tight silk channels have fewer problems with CEW. Conversely, plants that experience water stress during ear formation, resulting in the tip of the ear being exposed, are much more likely to experience problems with many of the ear pests, including CEW and sap beetles.

Figure 1. Caterpillar feeding damage to leaves and tassel may have been caused by corn earworm or fall armyworm.

Figure 2. Corn earworm moth.

Figure 3. Early instar corn earworm larvae and ear damage.

Figure 4. Middle instar corn earworm larvae.

Figure 5. Middle instar corn earworm larvae.

Figure 6. Fall armyworm moth.

Figure 7. Fall armyworm larvae.

Figure 8. Fall armyworm larvae in ear tip.

Figure 9. Fall armyworm larvae and damage on side of the ear.

Figure 10. Caterpillar damage on side of the ear most likely caused by fall armyworm.

Figure 11. Lesser cornstalk borer larva and silken tube.

Figure 12. Southern green stink bug adult.

Figure 13. Brown stink bug adult.

Figure 14. European corn borer larva.

Figure 15. Cutworm larvae and damage to seedling corn.

Figure 16. Corn leaf aphid.

Figure 17. Twospotted spider mite.

Figure 18. Sap beetle adults and damage to ear.

Figure 19. Silk fly larvae and damage to ear.

Weed Control

A. Stanley Culpepper and Lynn Sosnoskie, Extension Agronomists – Weed Science

Effective weed management is a critical component of successful sweet corn production. Weeds compete with sweet corn for light, nutrients, water and space as well as interfere with harvesting practices. Additionally, weeds can harbor deleterious insects and diseases. Severe weed infestations can eliminate sweet corn production if the weeds are left uncontrolled.

Weeds that usually cause problems in sweet corn are summer annual weeds including Texas millet and other grasses, yellow and purple nutsedge, morningglory and pigweeds.

An integrated program using a diversity of cultural control tactics, mechanical control tactics and herbicides will likely be the most effective and economical method to manage weeds.

Cultural Control Methods

Weeds can be controlled effectively through cultural practices that result in rapid sweet corn canopy establishment, thus providing an undesirable environment for weed growth. Cultural practices may include the following: 1) planting seeds free of weeds; 2) good seedbed preparation; 3) proper fertilization and watering; 4) following recommended row spacing; and 5) managing diseases and insects.

Site selection also can play a significant role in weed management. *Rotation* away from fields infested with troublesome weeds may minimize the presence of these weeds and allow for the use of alternative crops and control methods. To prevent weed spread from field to field during harvest, equipment and personnel should be cleaned when moving from more heavily infested to less infested areas. This precaution can help prevent or minimize the introduction of new weed species into 'clean areas.'

A *stale seedbed* weed management program can be extremely effective in most vegetable crops; however, its value in sweet corn is somewhat less than in other vegetables because of the numerous herbicides available for the sweet corn producer. Although this approach is not commonly used in sweet corn, it can be beneficial in areas where herbicide use is limited or in areas where difficult-to-control weeds are present. In a stale seedbed approach, the land is prepared two weeks or more before planting to allow for the greatest weed flush to occur prior to planting the crop, thereby allowing for the use of non-selective herbicides (e.g., glyphosate [Roundup] or paraquat [Gramoxone]) to control emerged weeds at or prior to planting.

Mechanical Control Methods

Mechanical control methods include field preparation by plowing or disking, cultivating, mowing, hoeing and hand pulling weeds. It is essential that the crop is planted into a clean seedbed, thus primary tillage or burndown herbicides must be used to control any emerged weeds at planting. When using a systems approach including both herbicides and cultivation, it is important to remember that the activity of a residual herbicide is most often destroyed by the cultivation process, thereby increasing the need for an additional herbicide application after cultivating.

Developing an Herbicide Program

Before selecting herbicides, growers should know what weeds are present or expected to appear, the soil characteristics (such as texture and organic matter content), the capabilities and limitations of the various herbicides, and how best to apply each herbicide.

<u>Weed Mapping</u>

The first step in any weed management program is to identify the problem. This task is best accomplished by weed mapping. Surveys should be conducted each fall to provide a written record of the species present and their population levels. The most commonly occurring weed species in the fall are likely to be the most common weeds in the following spring-planted crop.

In-season Monitoring

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

Proper weed identification is necessary since weed species respond differently to various herbicides. For assistance in identifying weeds contact your local county Extension office.

Herbicides:

Unlike most vegetables, numerous herbicides are labeled for use in sweet corn. Properly selecting and applying herbicides will provide effective weed management. Herbicides may be classified in several ways depending on how they are applied and their mode of action in or on the plant. Generally, herbicides are either soil-applied or foliage-applied. They may be selective or non-selective, and they may be either contact or translocated through the plant. For example, paraquat (Gramoxone) is a foliage-applied, contact, non-selective herbicide, while metolachlor (Dual) usually is described as a soil-applied, translocated, selective herbicide.

Foliage-applied herbicides may be applied to plant leaves, stems and shoots. Herbicides that kill only those parts of plants that the spray touches are contact herbicides. Herbicides that are taken into the plant and are moved throughout the plant are translocated herbicides. Paraquat (Gramoxone) is a contact herbicide; glyphosate (Roundup) and sethoxydim (Poast) are translocated herbicides.

For foliage-applied herbicides to be effective, they must enter the plant. Good coverage is critical and these products often require the addition of some type of adjuvant. Soil-applied herbicides are either applied to the surface of the soil or incorporated into the soil. Lack of moisture or rainfall following application of soil-applied herbicides often results in poor control. Many herbicides applied in Georgia offer residual weed control for the crop in which it was applied. Before applying any herbicide in sweet corn, review the herbicide label and the information on rotation restrictions to prevent future crop injury.

Table 1 includes the more commonly used herbicides for sweet corn production in Georgia.

Controlling Various Troublesome Weeds

This discussion is based on the current herbicide labeling for 2011. Refer to the most recent herbicide labels or your local county Extension office to determine that the following information is current for Georgia sweet corn production. Refer to the most recent label and the *Georgia Pest Management Handbook* for application timings, rates and restrictions (especially rotation restrictions) for the herbicides discussed below.

Texas millet is by far the most problematic weed in sweet corn production in Georgia. An extremely effective program consists of Bicep II Magnum (Dual II Magnum plus atrazine) applied within 24 hours of planting followed by a topical application of Laudis when Texas millet is 2 inches or less and sweet corn is between emergence and the V7 stage of growth. The addition of 0.5 lb ai/A of atrazine with Laudis is recommended if broadleaf weeds are present and corn is less than 12 inches. Use a methylated seed oil at 1% v/v and nitrogen (1.5 qt/A UAN or 1.5 lb/A AMS) when applying Laudis. If weeds are up when applying the Bicep II Magnum at planting, the addition of Gramoxone or Roundup is needed.

Yellow and Purple nutsedge can be controlled effectively by applying Sandea 75 DF at 0.67 oz/A plus a nonionic surfactant overtop of sweet corn when it is between the spike stage and 12 inches in height (so as to not inhibit spray coverage on the nutsedge). In fields where a severe nutsedge infestation is present, an herbicide may be needed at planting to allow the corn to maximize early season growth. In this situation, EPTC should be incorporated in the soil just prior to seeding sweet corn. In cool, wet conditions EPTC can cause some crop injury but the crop nearly always recovers.

Morningglory, Purslane and Pigweed can all be controlled effectively with atrazine-based programs, such as Bicep II Magnum (Dual II Magnum + atrazine) applied at planting followed by a postemergence application of atrazine (add Laudis if grasses are emerged and limit atrazine to 0.5 lb ai/A if mixing with Laudis). Do not use more than 2.5 lb ai/A/year of atrazine and refer to the most recent label for rotational restrictions.

Table 1. Herbicide options for sweet corn weed control.

Crop/ Application Timing	Weed	Formulation	Rate Per Acre Broadcast		Remarks and Precautions Always refer to the label to determine tank mix partners and crop rotation restrictions
			Amount of Formulation	**Pounds Active Ingredient**	
Preplant	Contact kill of all green foliage	paraquat (Firestorm, Parazone) 3SL (Gramoxone Inteon) 2SL	 1.3 to 2.7 pt 2.0 to 4.0 pt	0.49 to 1.0	Apply to emerged weeds but before crop emergence. Add 1 qt nonionic surfactant or 1 gal crop oil concentrate per 100 gal spray mix.
	Most emerged weeds except for resistant pigweed or horseweed	glyphosate (numerous brands) 4 SL 5 SL 5.5 SL 6 SL	 1 to 3 pt 0.8 to 2.4 pt 11 to 32 fl oz 10 to 30 fl oz	0.5 to 1.5	Apply to emerged weeds before seeding. Do not feed crop residue to livestock for 8 weeks following treatment. Perennial weeds may require higher rates. Some formulations may require additional adjuvant.
	Annual broadleaf weeds including morningglory, spiderwort, and very small pigweed	carfentrazone (Aim EC) 2.0 EC (Aim EW) 1.9 EW	0.8 to 2 fl oz	0.013 to 0.031	Apply prior to planting to weeds less than 3 inches. Coverage is essential for weed control. Add a nonionic surfactant at 1 qt per 100 gal of spray mix.
Preplant incorporate	Most annual grass and broadleaf weeds including fall panicum, seedling johnsongrass, signalgrass, and nutsedge	EPTC (Eradicane) 6.7 EC	4.75 pt	4	Apply and incorporate immediately just prior to seeding sweet corn. Application and incorporation gives the best control. A two pass incorporation is often required for nutsedge. Can be very effective on nutsedge if applied properly. Crop injury and reduced weed control may occur early in the growing season when conditions are cool and wet.

Crop/ Application Timing	Weed	Formulation	Rate Per Acre Broadcast		Remarks and Precautions Always refer to the label to determine tank mix partners and crop rotation restrictions
			Amount of Formulation	Pounds Active Ingredient	
Preemergence (PRE)	Most annual grasses including fall panicum and broadleaf signalgrass; only suppression of Texas millet; also controls pigweed species and suppresses yellow nutsedge	alachlor (Micro-Tech) 4 FME	2 to 2.75 qt	2 to 2.75	Apply to soil surface immediately after planting. Use low rate on coarse textured soils and higher rates on medium textured soils. High rates improve control of ragweed and lambsquarters. Performance is improved if rainfall or irrigation is received within 7 d of application.
		dimethenamid (Outlook) 6 EC	12 to 16 oz	0.56 to 0.75	Apply to soil surface immediately after planting or postemergence to corn up to 12 inches tall. Use lower rates on sandy soils. Do not use as a layby application.
		S-metolachlor (Dual II Mag.) 7.64 EC	1 to 1.67 pt	0.95 to 1.6	Apply to soil surface immediately after planting. Use lower rates on coarse soils or soils with less than 3% organic matter.
	Most annual broadleaf and grass weeds	atrazine (various brands) 4 L 90 WDG	 1 to 2 qt 1.1 to 2.2 lb	1 to 2	Apply to the soil surface immediately after planting. Requires rainfall or shallow cultivation for good control. Does not control fall panicum, Texas millet, or crabgrass. May be tank mixed with metolachlor, alachlor, dimethenamid, glyphosate, paraquat, or bentazon. Check label for directions and rotational restrictions.
		simazine (Princep) 4 L (Princep Caliber 90) 90 WDG	 1 to 1.2 qt 1.1 to 1.3 lb	1 to 1.2	Apply to soil surface immediately after planting. Requires rainfall or shallow cultivation for good control.
		alachlor + atrazine Bullet) 4 F (Lariat) 4 F	 2.5 to 3.75 qt 2.5 to 3.75 qt	1.5 to 2.3 + 0.9 to 1.4	Apply to soil surface immediately after planting. Requires rainfall or overhead irrigation within 7 d of application for activation. Use lower rates on coarse soils and/or with less than 3% organic matter. Check rotational restrictions and label for further instructions.
		dimethenamid + atrazine (Guardsman MAX) 5 F	2.5 to 4 pt	0.73 to 1.2 + 0.83 to 1.4	Apply to soil surface immediately after planting. Requires rainfall or overhead irrigation within 7 d of application for activation. Use lower rates on coarse soils and/or with less than 3% organic matter.

Crop/ Application Timing	Weed	Formulation	Rate Per Acre Broadcast		Remarks and Precautions Always refer to the label to determine tank mix partners and crop rotation restrictions
			Amount of Formulation	Pounds Active Ingredient	
Preemergence (PRE)	Most annual broadleaf and grass weeds	S-metolachlor + atrazine (Bicep II Magnum, Bicep II Magnum FC) 5.5 F	1.3 to 2.6 qt	0.78 to 1.56 + 1 to 2	Apply to soil surface immediately after planting. Requires rainfall or overhead irrigation within 7 d of application for activation. Use lower rates on coarse soils and/or with less than 3% organic matter.
		S-metolachlor + atrazine (Bicep Lite IIMagnum) 6F	0.9 to 1.9 qt	0.75 to 1.6 + 0.60 to 1.27	Apply to soil surface immediately after planting. Requires rainfall or overhead irrigation within 7 d of application for activation. Use lower rates on coarse soils and/or with less than 3% organic matter.
		S-metolachlor + atrazine + mesotrione (Lexar) 3.75 F	3 qt	1.31 + 1.31 + 0.17	Apply to soil surface immediately after planting.
Postemergence (POST)	Most annual broadleaf weeds	atrazine (various brands) 4 F 90 WDG	1 to 2 qt 1.1 to 2.2 lb	1 to 2	Apply overtop before corn exceeds 12 inches in height and weeds exceed 1.5 in. in height. Addition of crop oil concentrate improves activity on weeds but may result in some foliar burn of the crop. See label for rotational concerns and the amount of crop oil needed. If a PRE treatment was used, do not exceed a total of 2.5 lbs/ai/A per calendar year.
	Annual broadleaf weeds including pigweeds, very small grasses	mesotrione (Callisto) 4 L	3 fl oz	0.094	Apply overtop up to the 8-leaf stage of corn to actively growing small weeds (less than 4 inches). Addition of non-ionic surfactant at 1 qt per 100 gallons of spray mix is recommended, however crop oil concentrate may be used at 1 gallon per 100 gallons of spray mix. The addition of crop oil will increase weed control but may increase corn injury. Rotation to peas, beans, cucurbits and most other vegetables is 18 months. Do not apply any organophosphate or carbamate insecticide within 7 d of mesotrione as severe injury can occur.

Crop/ Application Timing	Weed	Formulation	Rate Per Acre Broadcast: Amount of Formulation	Rate Per Acre Broadcast: Pounds Active Ingredient	Remarks and Precautions Always refer to the label to determine tank mix partners and crop rotation restrictions
Poste-mergence (POST)	Residual control of annual grasses and small-seeded broadleaf weeds	pendimethalin (Prowl) 3.3 EC (Pendimax) 3.3 EC (Prowl H20) 3.8 AS	 1.8 to 2.4 pt 1.8 to 2.4 pt 2.0 pt	 0.75 to 1.0 0.75 to 1.0 0.95	May be applied from early postemergence until sweet corn is 20 to 24 inches tall or has 8 visible leaf collars (V8), whichever is more restrictive. Drop nozzles would be more effective in larger corn. **Does not control emerged weeds.** Do not apply in reduced tillage programs.
	Control of most broadleaf weeds; residual control of grasses	pendimethalin (Prowl, Pendimax) 3.3 EC + atrazine (AAtrex) 4 F	 1.8 to 2.4 pt + 1 to 2 qt	 0.75 to 1.0 + 1 to 2	When using Prowl: Apply tank mix from early postemergence until corn is 12 in. tall or has 8 visible leaf collars whichever is more restrictive. When using Pendimax: Apply tank mix from spike through the 4-leaf stage but before weeds exceed 1 in. in height.
	Control of most broadleaf weeds, residual control of most annual grasses with suppression of Texas millet	dimethenamid (Outlook) 6 EC + atrazine (AAtrex) 4 F 90 WDG	 8 to 16 oz + 1 to 2 qt 1.1 to 2.2 lb	 0.38 to 0.75 + 1 to 2	Apply overtop of corn (8 in. or less) before weeds exceed the two-leaf stage. Larger weeds will not be controlled. Also available as the commercial products Guardsman MAX. Do not use as a layby application. Do not apply within 50 days of harvest. If a PRE treatment was used, do not exceed a total of 2.5 lbs/ai/A per calendar year.
		S-metolachlor (Dual II Mag.) 7.64 EC + atrazine (AAtrex) 4 F 90 WDG	 1 to 1.67 pt + 1 to 2 qt 1.1 to 2.2 lb	 0.95 to 1.6 + 1 to 2	Apply overtop of corn (5 in. or less) before weeds exceed the two-leaf stage. Larger weeds will not be controlled. Also available as the commercial product Bicep II Magnum. Do not harvest within 30 days of application. If a PRE treatment was used, do not exceed a total of 2.5 lbs/ai/A per calendar year.
	Cocklebur, ragweed, jimsonweed, smartweed, smallflower morningglory	bentazon (Basagran) 4 SL	 1 to 2 pt	0.5 to 1.0	Apply when corn has 1 to 5 leaves. Add crop oil concentrate at 1 qt/A. See label for special recommendations for controlling yellow nutsedge.

Crop/ Application Timing	Weed	Formulation	Rate Per Acre Broadcast		Remarks and Precautions Always refer to the label to determine tank mix partners and crop rotation restrictions
			Amount of Formulation	Pounds Active Ingredient	
Postemergence (POST)	Broadleaf weeds including clover, sowthistle, cocklebur, jimsonweed, ragweed	clopyralid (Stinger) 3 EC	0.3 to 0.67 pt	0.13 to 0.25	Processing sweet corn only. Apply after sweet corn emergence up to 18 in. tall with weeds less than 5 leaf and actively growing. Will control most legumes. Do not apply within 30 days of harvest.
	Cocklebur, pigweed, lambsquarters, morningglory, sicklepod, and many other annual broadleaf weeds	2,4-D amine (various brands) 3.8 SL	0.5 to 1 pt	0.24 to 0.48	Use 0.25 lb a.i. of 2,4-D overtop when corn is 4 to 5 in. tall and weeds are small. Increase rate to 0.5 lb a.i. as corn reaches 8 in. **Use drop nozzles and direct spray toward base of corn that is over 8 inches.** Do not apply over open whorls. 2,4-D applied overtop of corn can cause injury. Do not use adjuvants. Reduce rate of 2,4-D if extremely hot and soil is wet. Do not cultivate for at least 10 days after application as corn may be brittle. Do not apply within two weeks of tasseling. Be careful to avoid drift to sensitive crops such as cotton, peaches, grapes, and other vegetables.
	Nutsedge, cocklebur, passionflower (maypop), non- ALS resistant pigweed, smartweed (Pennsylvania)	halosulfuron (Sandea) 75 DF	0.67 oz	0.032	Apply overtop or with drop nozzles to sweet corn from spike to layby for control of emerged weeds. Add non-ionic surfactant at 1qt per 100 gal of spray mix. All varieties have not been tested, test on a small acreage first. Not recommended for 'Jubilee'. Any injury arising from the use of halosulfuron is the responsibility of the grower. See label for tank mix partners including atrazine. **Rotational restrictions are a significant concern, see label.**

Crop/ Application Timing	Weed	Formulation	Rate Per Acre Broadcast		Remarks and Precautions Always refer to the label to determine tank mix partners and crop rotation restrictions
			Amount of Formulation	Pounds Active Ingredient	
Postemergence (POST)	Small pigweed and the best option for 1 to 2 inch grasses including Texas millet	tembotrione (Laudis) 3.5 SC	3 oz	0.082	Apply in sweet corn from emergence to V7 stage of growth. Only 1 application may be made. Can be tank-mixed with atrazine at 0.5 lb ai/A if corn is less than 12 inch. Use a methylated seed oil at 1% v/v and nitrogen (1.5 qt/A UAN or 1.5 lb/A AMS). Rain free period is 1 hour. Label rotation restriction is 18 month for most vegetables. Do NOT apply to Merit or Shogun cultivars, limited data is available on other cultivars thus one should try limited acres first.
Postemergence Directed application ONLY.	Contact kill of annual grasses and broadleaf weeds	paraquat (Firestorm) 3 SL (Gramoxone Inteon) 2SL	0.75 to 1.3 pt 1 to 2 pt	0.28 to 0.49	**Do not apply overtop or corn will likely be killed.** Suggest application as a hooded spray after corn reaches at least 10 inches in height. Use of a hooded or shielded sprayer will reduce crop injury as severe damage and/or complete kill can occur if spray contacts corn plants. Add a nonionic surfactant at a rate of 2 pt per 100 gal of spray mix.
	Small pigweed, nightshade, morningglory, common lambsquarters	carfentrazone-ethyl (Aim) 2 EC	0.5 to 1.0 fl oz	0.008 to 0.016	Apply postemergence (using drop nozzles) to actively growing SMALL weeds less than 3 inches, up to the 14 leaf collar stage of corn. Application should be directed after V8 stage of corn. Coverage is essential for control. Use nonionic surfactant at 1 qt per 100 gallons of spray mix. Mixing atrazine with Aim improves broadleaf weed control. Speckling of corn leaves should be anticipated under hot, humid conditions. Do not apply in conditions where drift is favorable.

Food Safety and Sanitation

Bill Hurst, Extension Food Scientist

Introduction

It is important that growers, shippers and their employees understand that good sanitation practices must be maintained throughout the production and handling of sweet corn. Pathogens harmful to humans can be transmitted by direct contact (infected humans or animals) or through contaminated water and soil. Once a vegetable is infected, pathogens are difficult or impossible to remove. Only by thorough cooking, pasteurization or irradiation, etc., will these pathogens be reliably eliminated. Below are some things growers and shippers can do on the farm and at the packinghouse to reduce the risk of contamination to their product.

Land History

Food safety is influenced not only by current agricultural practices, but also by former land use practices. Heavy metals and pesticide residues may persist in soils for long periods. Soils should be tested for unsafe levels of these compounds prior to planting. Also, land should be investigated for evidence that it was not formerly used for dumping hazardous industrial waste, which may have left toxic residues. If production land was previously used for agricultural purposes, review of pesticide records would reveal if proper pesticide management practices were followed. Production acreage should not have been previously used as a feed lot or for animal grazing, since pathogens associated with fecal contamination (i.e., *E. coli*) of the soil may persist.

Fertilizer Use

Improperly composted or uncomposted ***animal manure*** can be a potential source of human pathogens. Research by the University of California at Davis (UC-Davis) has shown that the survival rate of *E. coli* cells was 250 days when uncomposted dairy manure was incorporated into soil. If animal manure is to be applied as a fertilizer, it first must be fully composted, unless it is to be applied more than 90 days before harvest (for crops that are not in contact with the soil). ***Fully composted*** means that the organic matter has been maintained at a temperature between 131°F and 170°F for at least three days in a static, aerated pile, or for 15 days using windrow composting, during which period the materials must be turned a minimum of five times (National Organic Program Fund Rule Sec. 205.203).

Inorganic fertilizers should be certified to be free of heavy metals and other chemical contaminants. ***Biosolids*** (human waste) should never come in contact with fresh sweet corn. Produce that falls on the ground, called *drops*, should be harvested only if the finished product is to receive a "kill-step" treatment, such as cooking or pasteurization. Drops should never be harvested for the fresh market.

Animal Exclusion

Most pathogens that are harmful to humans are carried by animals, (e.g., deer, cattle, racoons, birds, dogs, cats., etc.) and these bacteria can be transmitted to vegetables at any stage during production and handling. Exclude as many animals as possible from the fields. Any animal waste or carcasses should be removed immediately when possible and practicable. Carcasses should be incinerated or buried. Do not harvest vegetables near these areas. Field workers who come into contact with live animals, animal carcasses or waste should wash their hands thoroughly before continuing to work. Vegetables containing bird or animal feces should not be harvested. Keep domestic pets and children out of fields prior to and during harvest.

Irrigation Water

Irrigation water is another potential vector by which bacterial (human pathogens) and chemical (pesticides) contaminants may be brought into contact with fresh produce. Deep well water is less likely to be contaminated with human pathogens (sewage) than surface water (e.g., lakes, ponds, rivers, etc.). The longer water is in direct contact with fresh vegetables, the cleaner the water should be. Therefore, water supplies for overhead and furrow irrigation systems should be tested for the presence of *E. coli*, which is a useful indicator for fecal contamination and possible presence of other human pathogens. In a drip irrigation system, the irrigation water is usually applied under mulch, which offers some protection from contamination to the edible portion of the vegetable crop. Irrigation pump stations must also be monitored for contaminants such as scum buildup, animal presence, human or animal waste products, etc. Scum buildup can lead to biofilm formation by potential human pathogens inside the water transmission pipes. If the pump becomes contaminated, all water going through the pump, and anything that water is sprayed on, can become contaminated.

Frost Protection

Water used for frost protection is similar to that of irrigation and should also be as clean as possible (drinking water quality or *potable*) since it will come into direct contact with the edible portion of the sweet corn.

Pesticide Mixing

Since pesticide water comes into direct contact with the edible portion of vegetables, it should be of drinking water quality (potable). Groundwater sources are preferred since they should be reasonably pathogen-free. Surface water quality typically changes from day to day, and is subject to animal contamination. The best water to use is from a monitored municipal source. Pesticide usage should be in accordance with manufacturer recommendations as well as comply with federal, state and local ordinances. Monitoring and documentation of proper pesticide usage should be maintained to prevent unsafe or illegal residues from contaminating vegetables.

Field Sanitation

Culling – Recent evidence suggests that human pathogens multiply more readily in cull vegetables, especially those showing injury or decay symptoms. As a preventive measure, field workers should not harvest or handle culls because infection can spread from contaminated to healthy vegetables via the workers' hands or gloves. All culls should be left in the field or removed by a separate work crew.

Toilet Facilities and Hand Wash Stations – Portable field toilets and hand wash stations must be available and used by all harvest crew members. OSHA regulations require that there will be one portable toilet per 20 employees if pickers are in the field for more then three hours. Toilets should be convenient, clean, well-maintained and serviced. Toilets must be moved with the crews and kept within one-quarter mile at all times. They should be well stocked with toilet paper. They must never be emptied in the field or near surface water sources. Each field toilet must also have a hand wash station supplied with liquid soap dispensers, potable water, single-use paper towels and trash receptacles. Training, monitoring and enforcement of field worker hygienic practices, such as washing hands after using the toilet, are critical to reduce the risk of human pathogen contamination. Crew supervisors should set a good example for personal hygiene.

Field Equipment, Containers and Tools – Field equipment, such as harvesting aids, picking containers, knives, brushes, buckets, etc., can easily spread microorganisms to fresh produce. Harvest aids should be cleaned and sanitized daily to prevent cross-contamination between production lots and should not be placed directly in contact with soil when used in the field. Field containers, such as buckets and wire-bound crates, should be kept free of chemical and physical contaminants such as industrial lubricants, metal fasteners, nails, staples and wood splinters. Plastic bins and containers (e.g., recyclable plastic containers - RPCs) are recommended because they are easier to clean and sanitize than wooden bins and containers.

Sanitary Postharvest Handling

Employee Hygiene – In Georgia, sweet corn is hand harvested to improve selection for marketable ears. Field workers may contaminate the husks by simply touching them with an unclean hand or knife blade. It is recommended that all members of the harvest crew, including graders and packers, wear rubber or latex gloves. Gloves are easier to clean and sanitize than hands because they have no cracks and crevices for harmful pathogens to hide in. Sanitizing dip stations with 25-100 ppm chlorine solutions should be easily accessible to sanitize hands and gloves periodically during the work day.

Harvest crew supervisors must be able to recognize symptoms of illness (e.g., fever, diarrhea, vomiting, sore throat or jaundice). Workers who display illness should either have appropriate measures put in place to protect the product from exposure (e.g., gloves, a mask to prevent sneeze contamination, etc.), or, if allowed to work at all, be utilized in a capacity where no contact with fresh vegetables is made. Open wounds and infected sores on hands carry harmful pathogens. Crew leaders should examine all workers' hands for these conditions daily. A sealed covering, like a bandage, is not sufficient to prevent potential contamination. Workers must wear rubber or latex gloves over the bandage. The best method for reducing potential contamination from open sores and wounds on other areas of the body is to remove the affected employee from situations where they may come into contact with the produce, either directly or indirectly.

Knife Sanitation – Keeping knives clean and sanitary is as important as good personal hygiene in reducing risk of contamination. If knives are used, as when mechanically-harvested sweet corn is taken to a packing line, they should be collected at the end of each production day, washed and sanitized, preferably with a non-corrosive sanitizing solution. During the production day, knives should be placed in clean sanitizing solution over long work breaks (e.g., lunch, supper) in the field operation. Research at UC-Davis has demonstrated that the strength of chlorine in these hand and knife dip solutions should be maintained at 25 to 100 ppm free chlorine.

Container Cleanliness – Containers used for packing and shipping must be kept clean until used. Stored wire-bound boxes can easily become contaminated by rodents, insects and other animals. Check stored units for contamination prior to use, and clean any that have become soiled. Store empty wire-bounds separately from those already filled with sweet corn, any potential chemical contaminants or any other non-sanitary conditions (near waste receptacles, animal-infested areas, etc.). Empty wire-bound boxes should not be allowed to touch the ground in the field (or any unsanitary surface), as this may transfer pathogens from the soil to the container.

Pre-Cooler Facility

Before the cooling process begins, wire-bound boxes and pallets should be rinsed off to remove any dirt and debris brought in from the field. Employees who are handling sweet corn boxes should maintain clean hands and wear clean gloves. Unloading equipment (e.g., fork lifts) should be cleaned and sanitized on a regular basis to prevent cross-contamination between production loads. Airborne contamination (e.g., free-floating dust, dirt, etc.) in the pre-cooler facility should be kept to a minium. Domesticated pets and small children should be restricted from the pre-cooler area. All staging, cooling and storage areas should be regularly cleaned and monitored for animal and pest infestations.

Hydrocooler

Hydrocooling by showering large volumes of water from overhead spray nozzles is the most common method of pre-cooling sweet corn in Georgia. Water used in hydrocooling should be potable. Water in the reservoir tank should be potable and continuously treated with a sanitizer to render it free of harmful pathogens.

Chlorine is the most common sanitizer used in produce washes and hydrocooling. To render the water free of harmful pathogens, research at UC-Davis has demonstrated that the level of chlorine in hydrocoolers should be maintained at 75 to 100 ppm free chlorine with a pH between 6 and 7. Inexpensive free chlorine test kits may be purchased to monitor the proper levels. Alternatively, an *oxidation-reduction potential* (ORP) greater than 650 mV using any oxidative sanitizer will ensure that pathogenic bacteria in the water are killed on contact, according to UC- Davis research. Chlorine use prevents the cross-contamination of produce by reducing the bacterial load of the water, but it does not sterilize the produce. Rinsing the produce with cold chlorinated water reduces the number of microorganisms present on the surface of the produce, but it does not remove all bacteria. Hydrocoolers must be regularly cleaned and sanitized, with special emphasis on conveyor rollers, reservoir pans, spray nozzles, refrigeration coils, pumps and pump screens.

Cold Storage Facilities – Sanitation of cold storage facilities must not be overlooked. Specifically, refrigeration coils, refrigerator drip pans, refrigeration cases, forced-air cooling fans, drains, walls, floors and ceilings should be cleaned and sanitized on a regular basis. The human pathogen *Listeria moncytogenes* can multiply at refrigerated temperatures under moist conditions, and may contaminate sweet corn if condensation from the refrigeration unit or ceiling drips onto it. *L. monocytogenes* is a common environmental pathogen that is indigenous on fresh produce and may multiply on walls, in drains and in cooling systems. Comprehensive sanitation programs that target these areas in the cooler are instrumental in preventing the establishment of this foodborne pathogen.

Ice Injection – After hydrocooling and cold storage, slush ice (a mixture of ice and water) is pumped into each wire-bound box prior to truck shipment. Water used to make ice must be potable (drinking quality). The slurry mix reservoir must be kept free of human pathogens. Continuous treatment of the water with a sanitizer is necessary to ensure ice is free of human pathogens. Manufacturing, distribution and handling equipment used to make ice must be cleaned and sanitized on a routine basis. Icemaker troughs and screws must be kept free of dust, dirt, field debris, oil, grease and other known contaminants (e.g., algae, slime, mildew, etc.).

Refrigerated Transport

Transportation is one of the most often overlooked areas of food safety in handling fresh produce. Growers and shippers should develop a pre-load checklist and designate an employee to grade the internal body status (air chute, insulation, integrity, etc.) and sanitary condition (temperature, floor channels, etc.) of each shipping trailer prior to loading sweet corn boxes. Refrigerated trailers, especially the inside body, should be cleaned and sanitized on a regular basis. Requiring drivers to furnish a "truck wash slip" will help document the last time this was done. Trailers that have been used to transport live animals, animal products or toxic materials should not be used to transport fresh produce.

Harvest and Quality

Dan Maclean, Extension Horticulturist

Sweet corn is a highly perishable product. As a consequence, to ensure a high quality product from harvest to distribution and marketing, an efficient postharvest cooling operation is essential. The extent of a grower's ability to cool and handle the product in a timely manner will dictate whether the market is regional or local.

Harvest maturity

In general, sweet corn is suitable for harvest when the pollination silks are dried but before the outer leaves start to shed away and lose their green color. The sweet corn ear should feel firm to the touch, while the kernels should have a slightly milky or creamy appearance when squeezed. These visual cues correspond to the proper harvest maturity for both the traditional sweet and the supersweet corn varieties (though the sugar content is greater in the latter).

Harvest

Sweet corn harvest occurs in early summer in Georgia, when temperatures routinely reach 90°F. At these temperatures, the rates of respiration and deterioration are exceptionally high. Unless the grower is planning to market the corn on the same day, it is critical to cool the sweet corn as promptly as possible after harvest, and to then maintain the cold-chain through to market. If proper cooling is not performed, then substantial losses in quality, such as loss of sweetness and tenderness, will occur very quickly.

The respiration rate of sweet corn is extremely high, even at modestly warm temperatures. The respiration rate at 77°F is approximately 10 times greater than sweet corn held at 33°F. As a result, corn harvested and maintained at 77°F for one hour will have lost 10 hours of marketing life. If the pulp and kernel temperature is 90°F or higher, as can often occur during late morning or early afternoon harvest, or in the middle of a filled bin, a couple hours delay in cooling can quickly result in days of lost marketing potential. Considering that the expected maximum shelf-life of sweet corn is only five to seven days under optimal harvest and postharvest cooling and handling scenarios, the loss of one to two days is not insignificant. Even if the grower plans on marketing the fruit within 24-48 hours, delays in cooling will result in substantial losses in quality as the sugars are being converted to starch.

If harvesting sweet corn by hand, care should be taken to field-sort for quality. This will assist with the rapid cooling of the corn once it arrives at the packing shed. Husks should be handled gently. Ears are harvested by bending down and away from the main stalk. The shank should be trimmed short immediately to reduce excessive surface area for moisture loss. Corn should be screened for insect damage, inferior shuck coverage and disease. Also, careful removal of flag leaves will result in a more visually appealing product. If corn is being harvested mechanically, then these same quality criteria should be employed in the packing shed.

Harvest quality indices

To achieve the highest grade for fresh consumption, the sweet corn kernels should appear full or plump and have high percent milk of the kernels on the ear. The rows of kernels should be uniform and full. The sweet corn should be free from damage and defects, such as discoloration, insect damage, live insects, handling injury, decayed silks or inferior kernels. Packed containers should have ears of uniform size and quality, with properly trimmed shanks and no separated leaves.

Postharvest Cooling

Changying "Charlie" Li, Extension Engineer
Gary Hawkins, Extension Engineer

Sweet corn is usually harvested in early summer in Georgia with field temperatures higher than 86 °F. Sweet corn has a high rate of heat respiration, as shown in Table 1. Both the field heat and high respiration rate in sweet corn can promote the conversion of sugar to starch, which reduces the most important quality of sweet corn -- sweetness. To preserve the quality of sweet corn, it is important to remove the field heat as quickly as possible, and precool sweet corn to the optimal temperature (32 °F) and relative humidity (95%). In commercial practice, however, sweet corn is seldom cooled below 40 °F due to cooling cost considerations. Sweet corn should not be handled in bulk during cooling because the respirational heat can build up quickly inside the pile.

Table 1. Rate of heat respiration of sweet corn when stored at various temperatures (Data from USDA Handbook 66, 2004)

Stored temperature (°F)	Rate of heat respiration (Btu per ton per day)
32	9020
41	13860
50	23100
59	34980
68	57420
77	78980

There are several precooling options for sweet corn, such as hydrocooling, vacuum cooling, package icing and forced air cooling.

- **Hydrocooling** is the most widely used cooling method for sweet corn in both large and small operations. This cooling method uses cold water (either showering or immersing), which effectively cools the sweet corn. Research has shown that the immersing method can more efficiently cool sweet corn than the showering method. Another additional benefit is that the hydrocooling can avoid water loss of sweet corn. However, the sweet corn container must be water-tolerant, which might increase handling costs.
- **Package icing** is another precooling method that has been used commonly and proven to be effective in cooling sweet corn, especially for local and direct shipments. This cooling method can be used for both large and small operations. Package icing requires filling the sweet corn container with crushed or flaked ice during the packaging process and shipments. This method can provide fast cooling at the beginning, but its efficiency decreases as the ice melts. Therefore, refilling the ice in the container may be needed. Typically, ice weight that is equivalent to 20-30% of the sweet corn weight is needed for initial cooling. A general rule of thumb is that 2 to 3 pounds of ice is needed for every 10 pounds of sweet corn. One limitation of this cooling method is that the cooling ice can increase the freight load considerably. Another disadvantage is that this cooling method makes the packaging and transportation vehicle wet due to melt water.
- **Vacuum cooling** is another common method used to precool sweet corn and can be used for both large and small operations. This cooling method uses steam-jet pumps to pump out air from the air-tight container and to cause the moisture to evaporate. The sweet corn must be wet first and moisture evaporation reduces the temperature of the sweet corn. The vacuum cooling method can usually provide efficient and uniform cooling for sweet corn in large loads. One drawback of this cooling method is its high cost.
- **Forced air cooling** can be used for sweet corn precooling in small operations. Due to lower cooling efficiency and longer cooling time compared to above three cooling methods, forced air cooling is less commonly used for sweet corn.

After precooling, sweet corn should be put in cold storage right away. Sweet corn is usually not recommended for prolonged storage (>2 weeks) because its quality can deteriorate very quickly. Sweet corn should also be kept in a cold environment during shipment. Other than the refrigeration provided by the transportation vehicle, package icing is a common way to keep the sweet corn cool. To maintain good air circulation, however, the shipment temperature should be kept a little higher than the freezing temperature (32 °F).

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Marketing Analysis

Esendugue Greg Fonsah, Extension Economist
Sam Kaninda, Graduate Student, Department of Ag & Applied Economics

Sweet corn is amongst the most popular vegetables in both the U.S. and in Georgia. According to the Georgia Farm Gate Value Report, sweet corn ranked 2nd in acreage and 4th in the value of vegetables in 2009 (Table 1). Furthermore, this produce ranked 27th and 24th in the Georgia Agricultural commodity survey in 2008 and 2009, respectively (Boatright and McKissick, 2008; 2009). Sweet corn has a complex marketing system. It is consumed fresh and in many forms of processed products. It is also marketed through a wide range of distribution channels including various shipping operations, local wholesale and direct sale (Wen-fei Uva, 2001).

Table 1: Top Ten Georgia Vegetable Acreages and Farm Gate Value Ranks, 2009.

Rank	Crops	Total Acres	Rank	Crop	Total Value
1	Watermelon	24,238	1	Watermelon	$139,001,756
2	Sweet Corn	21,564	2	Bell Peppers	$129,281,103
3	Snap Beans	14,768	3	Onions	$126,107,748
4	Onions	12,993	4	Sweet Corn	$83,028,604
5	Cabbage	9,307	5	Tomato	$63,875,475
6	Cucumbers	8,757	6	Cucumbers	$52,572,483
7	Bell Peppers	8,737	7	Cabbage	$37,632,602
8	Southern Peas	8,153	8	Snap Beans	$35,276,063
9	Collards	6,943	9	Cantaloupe	$29,062,290
10	Turnip Greens	5,847	10	Carrots	$25,153,764
	Total Top Ten Acres	**121,307**		**Total Top 10 farm gate value**	**$720,991,888**
	Total Acreages	**161,959**		**Total Farm Gate**	**$915,632,787**
Source: Boatright and McKissick. 2009 Georgia Farm Gate Vegetable Report, AR-10-02, June 2010.					

Area Planted and Harvested

The production of sweet corn in Georgia has steadily increased between 1999 and 2009. With 22,000 acres planted and 21,000 harvested in 1999, production reached its peak in 2005 when 30,000 acres were planted and 29,000 acres harvested. In 2009, 26,000 acres were planted and 25,000 acres were harvested. Overall, the production of sweet corn in Georgia has increased from 1999 to 2009 (Fig.1)

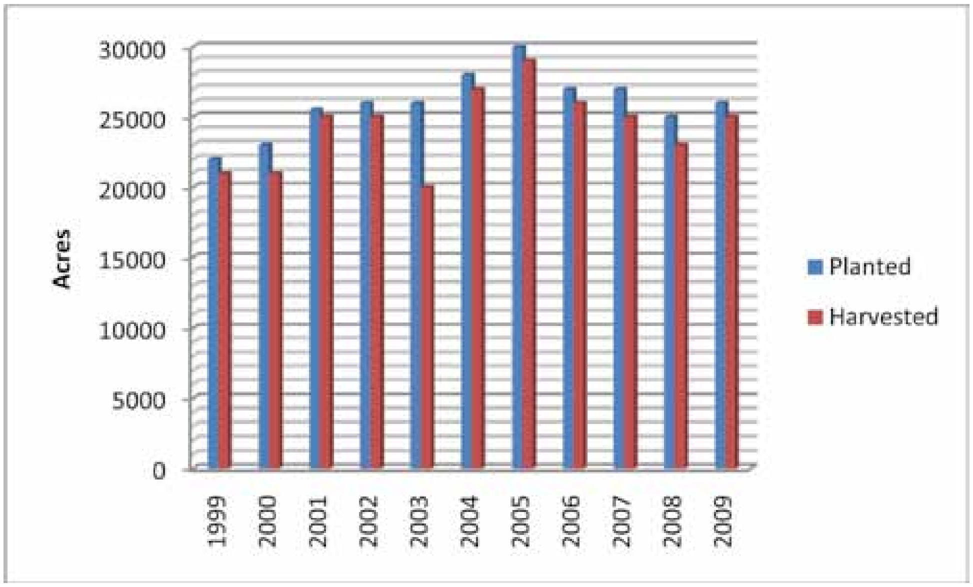

Fig. 1: Georgia Sweet Corn Area Planted and Harvested, 1999-2009
Source: Georgia Agricultural Statistics Service/USDA, 2002 Census of Agriculture Georgia Profile.
http://www.nass.usda.gov/QuickStats/PullData_US.jsp, accessed Jan. 20, 2011.

Yield Trend

Despite the significant increase of 45cwt/acre between 2007 and 2008 and a slight increase of 18 cwt/acre between 2002 and 2003, the sweet corn yield trend has been decreasing since 1999. In the past two decades, yields have declined from a peak of 180 cwt/acre in 1999 to as low as 130 produced cwt/acre. The worst year was 2006, where less than 110 cwt /acre were produced (Fig. 2).

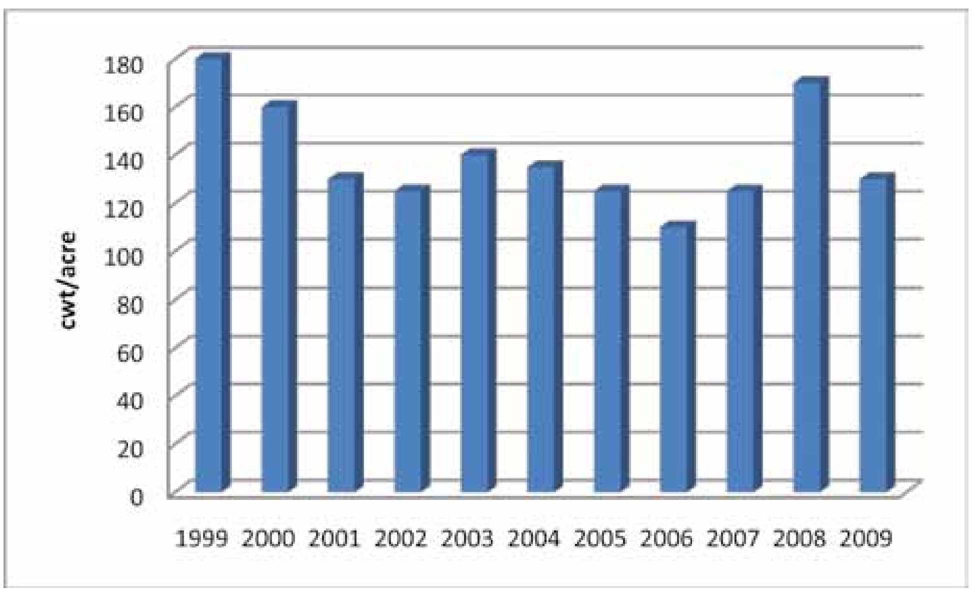

Fig. 2: Georgia Sweet Corn Yield Trend, 1999-2009.
Source: Georgia Agricultural Statistics Service/USDA, 2002 Census of Agriculture Georgia Profile.
http://www.nass.usda.gov/QuickStats/PullData_US.jsp, accessed Jan. 20, 2011. 1 cwt = 100 pounds

Production

In contrast to yield trends, the total production trends of sweet corn in Georgia have been inconsistent and fluctuating. However, five years that stand out distinctly. While 1993 had the lowest production of 780,000 cwt., 1999, 2004, 2005 and 2008 recorded production of more than 3,500,000 cwt., with 2008 being the peak production year at 3,910,000 cwt. Overall the production of sweet corn has increased from 1992 when 1,170,000 cwt. were produced to 2009 with 3,250,000 cwt produced (Fig. 3).

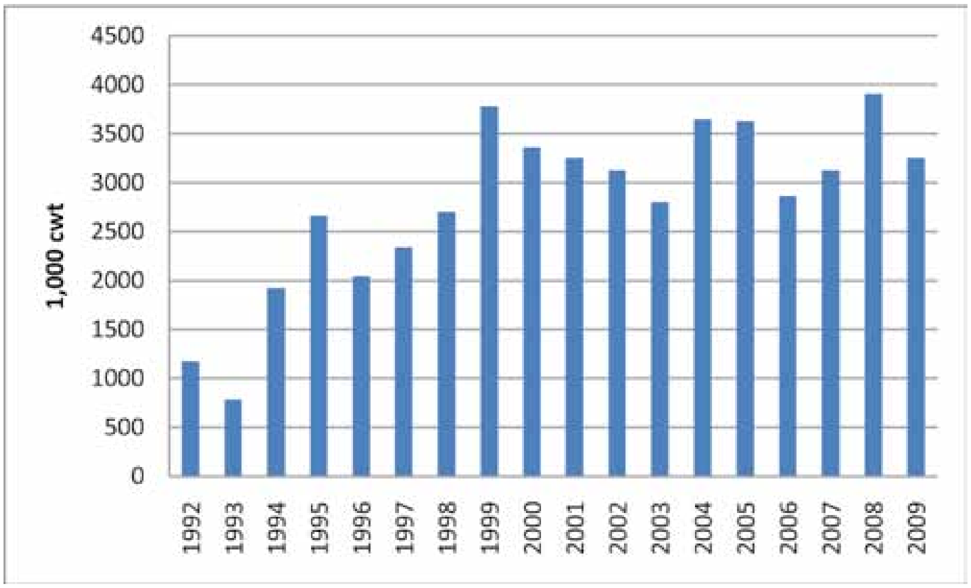

Fig. 3: Georgia Sweet Corn Production Trend, 1992-2009
Source: Vegetable and Melons Yearbook Data/#89011/May 20, 2010, ERS/USDA

Average Seasonal Price

During the last decade, the Georgia sweet corn industry received prices below $22/cwt. There were three years when prices were slightly above $20 per cwt. ($21.90/cwt in 2005, $20.6/cwt in 2006 and $20.90 in 2008). However, from 1999 to 2009, the overall price trend was upward sloping from $14.00 per cwt in 1999 to the peak of $26.2/cwt in 2009. Furthermore, the lowest price of $12.5/cwt was recorded in 2000 (Fig. 4). The highest price recorded in 2009 could be attributed to 16.9% decrease in production in the same time period. Compared to other vegetables such as snap beans, fresh tomato and onions, Georgia sweet corn growers received lower prices during the last decade. During the same time period snap beans and tomato growers received prices above $30/cwt.

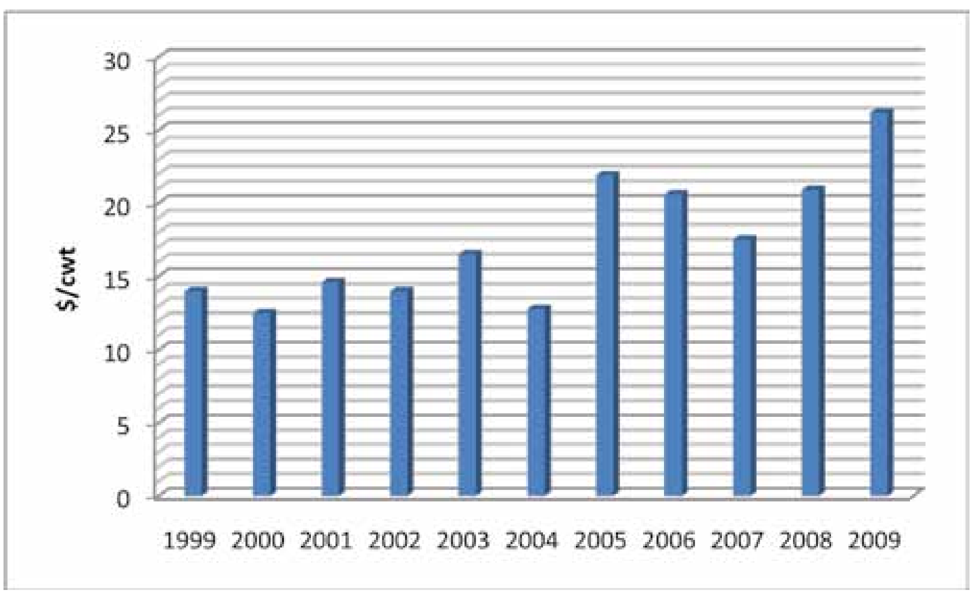

Fig. 4: Georgia Sweet Corn Price Trend, 1999 – 2009
Source: Georgia Agricultural Statistics Service/USDA, 2002 Census of Agriculture Georgia Profile.
http://www.nass.usda.gov/QuickStats/PullData_US.jsp, accessed Jan. 20, 2011.

Farm Gate Value

Despite low prices received by Georgia sweet corn growers, Georgia farm gate value for this crop has been high. The last decade was marked by values above $40 million. There were three exceptional years where the value was above $75 millions: 2005, 2008 and 2009 with $79.4 million, $81.7 million and $85.2 million, respectively. The lowest value of $42 million was in 2000 and the highest at $85.2 million was in 2009 (Fig. 5). High values observed in 2005 and 2008 can be attributed to high production as well as high prices during the same periods and the highest value in 2009 to high price recorded in the same year. Despite the high production in 1999 and 2004, Farm gate values for these years were lower than that of 2005 because of low prices recorded during those years.

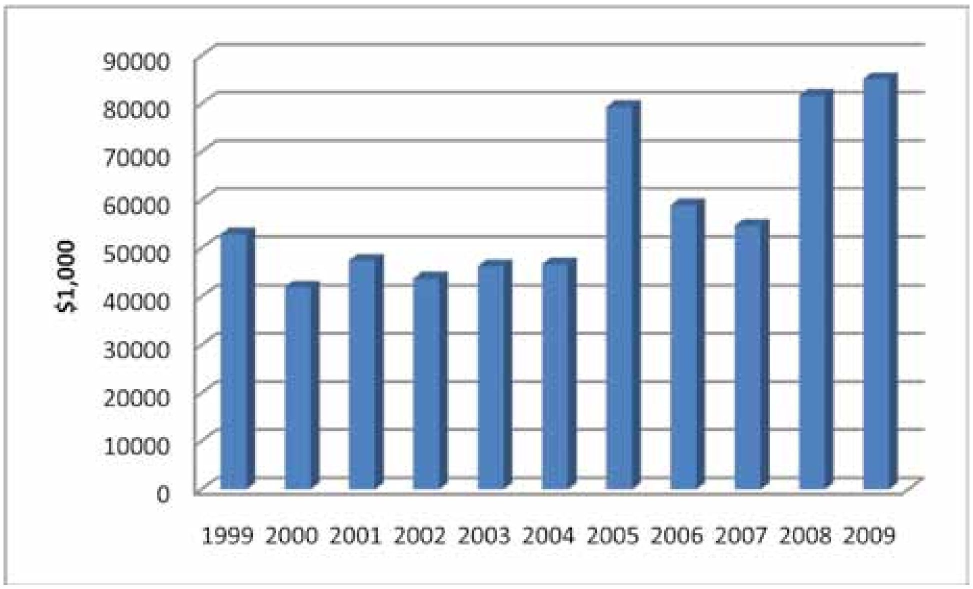

Fig. 5: Georgia Sweet Corn Farm Gate Value, 1999 – 2009
Source: Georgia Agricultural Statistics Service/USDA, 2002 Census of Agriculture Georgia Profile. http://www.nass.usda.gov/QuickStats/PullData_US.jsp, accessed Jan. 20, 2011.

U.S. Per Capita Consumption of Sweet Corn

Total per capita use of sweet corn in the U.S. has been steadily decreasing. For instance, the highest per capita consumption of all sweet corn (i.e., fresh, canned and frozen) was 28.34 lbs. in 1998 compared to 26 lbs. in 2010. A consistent downward trend was observed until 2006 when per capita consumption hit 26.1 lbs. Then sweet corn consumption regained momentum in 2007 at 28.1 lbs and suddenly took a 13.5% nose dive to 24.3 lbs in 2008. There is no logical explanation for the significant decline in consumption except that maybe consumers substituted other produce for sweet corn.

On the other hand, per capita use of fresh, canned and frozen sweet corn have all been slightly decreasing. Per capita use of sweet corn remained above 9 lbs. from 1998 to 2004, remained above 8 lbs. from 2005 to 2006 and regained the 9 lbs. status quo until 2010. Canned sweet corn maintained 9 lbs. and above from 1998 to 2000, dropped to 7.8 lbs. and above from 2001 to 2007 and finally dropped to 6.7 lbs. and above until 2010. It appears that Americans eat more frozen sweet corn than fresh and canned, respectively. The lowest per capita consumption of frozen sweet corn was 8.4 lbs. recorded in 2008. The peak consumption was 10.1 lbs. and 10.0 lbs. in 1999 and 2007, respectively. Otherwise, frozen consumption has remained at 9 lbs. and above since 1998 (Fig. 6).

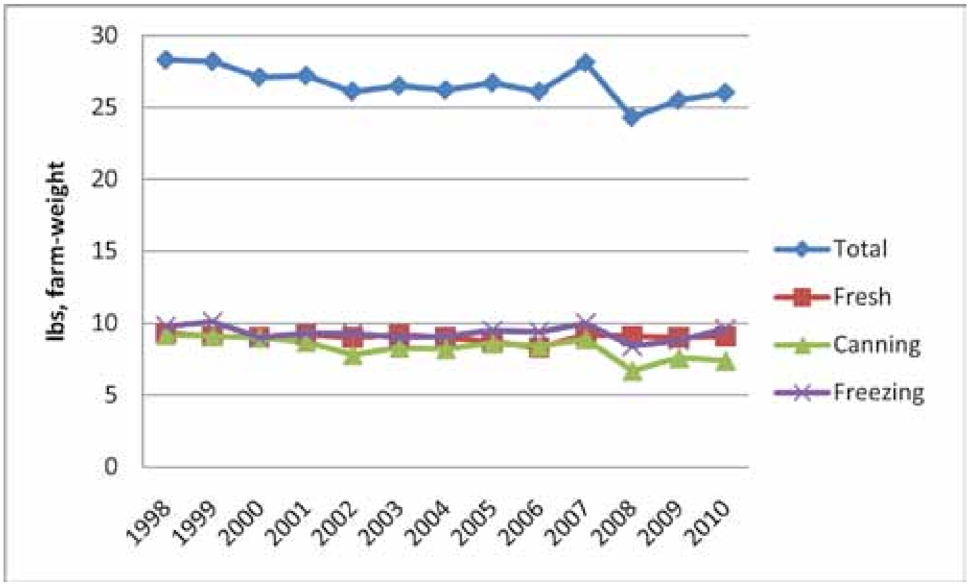

Fig. 6: Per Capita Use of Sweet Corn, fresh, canning and freezing, 1998-2010
Source: Vegetable and Melons Yearbook Data/#89011/May 20, 2010, ERS/USDA

U.S. Monthly and Average Seasonal Price Trend

The U.S. seasonal prices for sweet corn have been steadily increasing. From $18.50 per cwt. in 2000, the annual price for sweet corn reached $29.40 in 2010. The lowest price of $19.20/cwt. was recorded in three successive years: 2002, 2003 and 2004 (Table 2). During the same period, there was lot of fluctuation in monthly prices. For spring production, the highest monthly price of $59.30/cwt. was recorded in March 2009 and for the same year the lowest price was $20.80 in May. Meanwhile in the fall production of the same year, the highest price was $23.70 per cwt in September and the lowest was $19.40 per cwt in December (Table 2).

Table 2: U.S. Monthly and Average Seasonal Price of Sweet Corn, 2000-2010

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Season average
-- Dollars per cwt --													
2000	31.50	25.10	19.30	18.70	14.40	18.00	22.00	20.70	20.10	24.00	16.80	33.00	18.50
2001	33.50	34.00	26.10	18.10	24.70	18.70	19.60	18.90	18.80	23.80	18.40	17.50	19.50
2002	23.80	22.90	25.20	17.70	17.20	18.60	24.50	20.90	21.80	22.10	16.80	16.50	19.20
2003	27.70	24.00	18.90	14.90	16.50	16.90	20.00	19.60	19.70	22.90	27.30	33.70	19.20
2004	30.30	20.90	20.30	17.20	15.60	12.50	16.60	20.90	21.30	27.50	29.30	18.10	19.20
2005	21.30	28.60	26.10	21.50	18.00	22.50	22.30	20.40	24.70	25.50	25.70	22.40	22.10
2006	35.00	35.00	34.00	27.10	15.40	21.50	21.00	21.70	25.10	21.10	20.70	20.80	23.00
2007	27.40	23.60	30.20	25.60	21.40	17.30	22.20	22.80	23.20	21.40	20.60	34.10	22.70
2008	30.80	23.00	28.60	20.40	21.90	19.80	28.70	27.20	27.10	23.90	34.70	23.40	25.90
2009	24.90	46.40	59.30	33.10	20.80	25.30	34.60	26.40	23.50	23.40	19.50	22.70	29.30
2010p	37.80	58.50	62.70	40.10	25.10	16.00	20.20	23.10	24.00	28.00	20.60	31.60	25.70

p = Preliminary.
1/ Monthly prices are averages received at the f.o.b. shipping point through 2005. Thereafter, prices are measured at the point of first sale. The season average is the weighted average price received by producers at the point of first sale.
Source: USDA, National Agricultural Statistics Service Agricultural Prices.

World Acreage

The United States is ranked 1st in the world terms of sweet corn acreages. During the past decade, the United States harvested more than 600,000 acres except in 2008 where the area harvested was slightly below 600,000 acres (Table 3). The time periods 1998, 1999 and 2000 were three exceptional years when the area harvested was 704,700 acres, 703,600 acres and 705,800 acres, respectively. Overall, the United States has produced more than 23% of the total world acreages. Nigeria, Guinea and Indonesia are ranked 2nd, 3rd and 4th and they contributed 16.5%, 11.1% and 8.7% of the world total, respectively (Table 3).

Table 3: World Harvested Acreage of Fresh Market Sweet Corn, 1998 – 2008.

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
	1,000 acres										
United States	704.7	703.6	705.8	698.0	662.8	673.4	648.5	641.5	616.2	601.6	593.4
Nigeria	395.4	395.4	395.4	395.4	397.8	397.8	397.8	399.1	400.3	401.5	401.5
Guinea	259.5	259.5	259.5	259.5	259.5	259.5	259.5	259.5	271.8	284.2	286.6
Indonesia	237.2	212.5	215.0	202.6	192.7	207.6	207.6	224.9	207.6	224.9	224.9
Côte d'Ivoire	168.0	168.0	168.0	177.9	177.9	177.9	177.9	177.9	177.9	177.9	177.9
Others	780.1	793.6	797.6	851.0	900.5	908.0	929.7	924.7	924.7	894.9	891.2
World	2,544.9	2,532.6	2,541.3	2,584.4	2,591.2	2,624.2	2,621.0	2,627.6	2,598.5	2,585.0	2,575.5
Source: Vegetable and Melons: Yearbook Data /#89011/May 20, 2010, Economic Research Service, USDA.											

World Production

The United States is also ranked 1st in the production of sweet corn in the world. In 2000, 2002, 2004, 2006, 2007 and 2008, the United States produced slightly below 90 million cwt. However, in 1998, 1999, 2001, 2003 and 2005, the production was above 90 million cwt. In 2008, the United States produced 89.3 million cwt., equivalent to 42.8% of the world sweet corn harvest of 208.7 million cwt. Mexico, Nigeria, Hungary and France contributed 6.9%, 6.1%, 5.4% and 5.0%, respectively, during the same year. The highest world production level was reached in 2007 and 2008 with a total production of 208.7 million cwt. (Table 4).

Table 4: World Production of Fresh Market Sweet Corn from Selected Countries, 1998-2008

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
	Million cwt										
United States	91.4	91.7	89.5	90.2	87.8	93.8	87.2	90.5	88.5	89.3	89.3
Mexico	5.6	6.8	7.6	10.2	11.5	11.1	13.0	13.8	14.3	14.3	14.3
Nigeria	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.8	12.8
Hungary	4.5	5.6	6.4	9.2	10.3	12.5	11.2	7.8	11.3	11.3	11.3
France	11.0	9.8	10.0	9.8	11.6	11.2	11.5	10.9	10.2	10.5	10.5
Others	64.7	64.5	63.8	66.5	66.6	68.8	69.7	68.7	68.8	70.5	70.5
World	189.8	191.1	190.0	198.5	200.6	210.1	205.4	204.5	205.9	208.7	208.7
Source: Vegetable and Melons: Yearbook Data /#89011/May 20, 2010, Economic Research Service, USDA.											

Import Trade

Even though the United States is the largest producer of fresh sweet corn, it also imports this commodity from different countries. In 2009, the U.S. import value for sweet corn reached $24.4 million. The major exporters of sweet corn to the United States are Canada and Mexico, which are NAFTA countries. Other minor suppliers included Guatemala and Peru (Table 5).

Table 5: U.S. Import Value of Selected Fresh Vegetable from Selected countries and the World, 2009.

	Canada	Mexico	Guatemala	Peru	Chile	Netherlands	Other	World
	-- $ 1,000 --							
Asparagus	5,076	146,769	27	161,847	164	0	972	314,855
Beans, snap	881	38,641	16,444	758	0	0	1,144	57,867
Broccoli	1,922	74,165	426	0	0	0	114	76,627
Cabbage	8,783	4,542	0	0	0	0	509	13,834
Cantaloupe	144	7,035	87,382	0	0	0	53,421	147,981
Carrots	34,436	12,263	728	0	0	0	2,011	49,438
Cauliflower	5,784	3,375	206	0	0	0	0	9,365
Celery	1,171	9,428	0	0	0	0	22	10,621
Sweet corn	1,881	22,328	92	12	0	0	118	24,431
Cucumbers	85,240	238,449	18	0	0	2,063	9,920	335,690
Eggplant	2,178	42,581	112	0	0	1,468	5,512	51,851
Garlic	498	4,596	0	86	379	0	61,000	66,558
Lettuce, all	25,107	88,438	14	1,428	0	0	891	115,879
Onions	22,681	171,121	1,322	22,381	4,411	377	3,150	225,443
Okra	0	12,916	20	0	0	0	5,841	18,777
Green peas	321	14,168	21,492	10,087	0	0	98	46,167
Peppers, bell	165,838	293,114	1,290	18	0	39,829	25,505	525,593
Peppers, chile	34	216,167	21	123	0	187	5,443	221,975
Squash	2,261	176,887	539	28	190	149	4,732	184,786
Tomatoes	255,521	1,125,527	3,981	0	0	12,500	6,053	1,403,583
Watermelon	510	203,761	8,761	0	0	0	6,690	219,722
Selected total	620,267	2,906,269	142,877	196,768	5,143	56,573	193,146	4,121,043
Source: USDA, Economic Research Service using data provided by U.S. Department of Commerce, U.S. Census Bureau.								

Export Trade

As the largest producer of fresh sweet corn, the United States exports some of its production to various countries. The U.S. exports have been steadily increasing since 1990. However, between 1900 and 2000, more fluctuations were recorded in the quantity exported. Quantity exported fluctuated between 70 million and 109 million pounds. From 2000, the quantity exported has steadily increased. From 101 million pounds in 2000, U.S. exports reached its peak in 2008 with more than 180 million pounds before falling to 149 million pounds in 2009. Heavy export activities take place in the summer months of May, June and July of each year (Table 6).

Table 6: U.S. monthly and annual export volume of fresh sweet corn, 1990-2010.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
	-- 1,000 pounds --												
1990	641	291	3,060	10,235	19,163	18,775	13,078	2,857	558	2,175	1,661	1,222	73,715
1991	2,103	1,108	2,402	4,956	18,577	17,717	10,892	2,924	596	2,260	2,630	2,344	68,508
1992	1,836	1,924	2,662	11,118	23,072	25,935	19,065	1,774	310	2,468	2,432	1,560	94,157
1993	1,641	1,422	2,271	3,922	16,533	20,189	18,181	3,936	1,695	1,890	2,398	1,410	75,489
1994	1,016	1,570	6,129	9,782	20,698	18,700	10,780	695	562	1,766	1,891	866	74,455
1995	5,526	1,920	8,835	18,108	27,517	18,368	11,239	2,006	2,550	4,760	3,231	5,433	109,492
1996	2,531	5,520	3,552	8,180	18,603	24,800	14,055	4,572	1,164	2,595	3,234	2,164	90,971
1997	1,685	1,664	16,958	34,178	1,729	16,094	20,227	3,115	2,887	2,341	2,714	1,791	105,384
1998	2,659	5,037	3,772	9,336	29,694	22,629	10,801	1,009	1,065	4,549	1,302	1,724	93,576
1999	1,599	2,225	3,632	19,556	19,579	22,487	12,557	2,100	502	2,150	1,467	1,328	89,181
2000	2,450	4,231	9,262	13,831	19,898	23,327	13,056	4,091	494	2,506	4,970	3,617	101,735
2001	3,553	2,190	4,656	20,793	20,438	26,577	15,038	3,795	3,388	4,003	3,912	5,002	113,346
2002	3,942	2,462	4,039	16,958	25,706	25,118	16,014	5,883	3,830	3,121	5,471	2,125	114,668
2003	4,580	4,347	9,822	20,960	23,459	25,959	24,626	4,360	1,967	3,639	4,359	5,285	133,363
2004	6,345	2,941	7,727	18,124	27,577	29,476	17,213	5,785	3,469	5,795	4,379	4,642	133,473
2005	4,660	5,636	8,694	20,981	27,171	26,950	17,207	5,162	5,054	5,558	5,454	3,452	135,978
2006	4,850	6,467	8,875	13,394	37,553	32,954	20,915	4,794	3,475	4,718	3,997	2,808	144,801
2007	4,814	4,647	8,245	14,513	30,801	33,594	20,604	2,269	1,772	3,937	3,044	2,917	131,156
2008	7,299	6,444	9,296	23,911	38,201	44,431	29,430	5,482	4,449	3,869	4,641	3,244	180,697
2009	5,195	5,400	7,594	14,781	35,366	30,783	17,290	6,114	6,209	9,976	5,525	4,864	149,097
2010	3,694	4,117	2,593	11,094	46,471	46,590	30,279	6,899	4,164	6,081	6,025	4,386	172,395
Source: Vegetable and Melons Outlook/VGS-342/December 16, 2010.													

Besides fresh sweet corn, the United States also exports frozen sweet corn. Japan is the number one importer of frozen sweet corn from the U.S. followed by China, Mexico, Canada and Saudi Arabia. Other importing countries with less than $2 million in value are Hong Kong, Australia, Taiwan, South Korea and the United Kingdom (Table 7). In 2009, the U.S. export value for frozen sweet corn was more than $70 million.

Table 7: U.S. Export of Frozen Sweet Corn to Selected Countries, 2009

Item	Australia	Canada	China	Hong Kong	Japan	Mexico	Saudi Arabia	South Korea	Taiwan	United Kingdom	Others	World
	$ 1,000											
Carrots	0	346	0	0	69	11	0	133	0	0	70	629
Sweet corn	488	3,287	10,841	1,433	34,655	6,717	2,026	164	307	11	10,113	70,041
Green beans	24	4,234	109	0	635	1,388	38	36	0	69	1,783	8,315
Green peas	595	4,211	874	26	3,054	3,774	6	68	43	0	2,305	14,958
Spinach	4	5,689	0	12	0	14	0	27	0	0	124	5,870
Selected total	1,110	17,768	11,824	1,471	38,413	11,904	2,070	428	350	80	14,395	99,814
Source: prepared by ERS using data provided by U.S. Department of Commerce, U.S. Census Bureau.												

Retail Prices

The U.S. average retail price for fresh sweet corn in January 2010 was higher than in 2008 and 2009.The peak retail price in 2010 occurred in March and then drastically down-trended until September. In 2009, after reaching a peak in March, the average retail price declined considerably in June. In addition, a relative peak was observed in July of the same year. The average retail price for sweet corn fluctuated a lot in 2008. However, a relative peak occurred in November of the same year (Fig. 7).

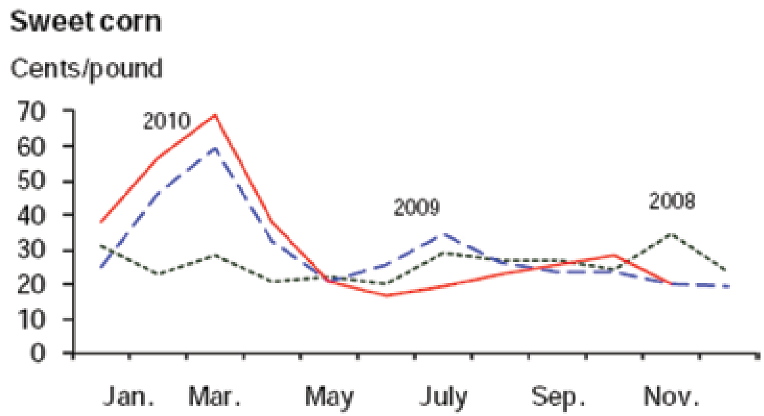

Fig. 7: U.S. Average Fresh Market Sweet Corn Retail Prices By Month: 2008-2010.
Source: Vegetable and Melons Outlook/VGS-342/December 16, 2010.

Conclusion

Sweet corn is an important horticultural crop for the state of Georgia in particular and the U.S. at large. In 2009, the Georgia Farm Gate Value Report showed that sweet corn ranked 2rd in acreage and 4th in the value of vegetables. The production of sweet corn in Georgia has been fluctuating since 1992. Overall, the production of sweet corn has increased from 1992 when 1,170,000 cwt. were produced to 2009 when 3,250,000 cwt. were produced. For the past two decades, sweet corn yields have declined from a peak of 180 cwt/acre in 1999 to as low as 130 cwt/acre in 2009. In contrast, despite low prices received by Georgia sweet corn growers from 1999 to 2009, the overall price trend was upward sloping from $14.0 per cwt. in 1999 to the peak of $26.2 in 2009. With over 85 million cwt per year, the United States has positioned itself as the number one producer of sweet corn in the world. Mexico, Nigeria and Hungary rank 2nd, 3rd and 4th, respectively.

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Production Costs

Esendugue Greg Fonsah, Extension Economist
Sebastain Awondo, Graduate Student, Department of Agricultural and Applied Economics

The success and resilience of most commercial vegetable enterprises today are deeply rooted in the ability to manage enterprise risk. Estimating cost of production is an important aspect of enterprise risk management, and a step necessary to determine whether the enterprise will be profitable or not. Managing risk is an equally important aspect in commercial sweet corn production. Growers often make use of enterprise budgets to determine the profitability of their business. An enterprise budget in this case includes cost estimates for those inputs necessary to achieve targeted sweet corn yields over the years it is produced. However, production practices vary among growers and thus require each grower to tailor budget estimates to reflect the individual situation with which they are faced (Fonsah and Hudgins, 2007; Fonsah et al. 2007; Fonsah, 2008; Fonsah et al, 2008). Detailed printed and computerized budgets are available in most county Extension offices and on the University of Georgia Department of Agricultural and Applied Economics website:
http://www.ces.uga.edu/Agriculture/agecon/printedbudgets.htm

Types of Costs

Economists generally classify total input cost accrued from a production process as either variable or fixed. Variable input cost, also known as operating cost, is the cost accrued from inputs that vary with the amount of sweet corn produced or the adopted sweet corn cultural practices. Some variable costs include seed, fertilizer, chemicals, fuel and labor. Within the budget estimates of sweet corn production, variable costs can further be grouped into pre-harvesting, harvesting and marketing operation costs. This breakdown provides growers with an opportunity to review their production costs at the different stages of the operation and production process (Fonsah et al., 2007; Fonsah et al., 2008; and Byrd et. al., 2006). Table 1 shows the pre-harvesting variable cost of sweet corn production in Georgia with a total pre-harvesting cost of $1,138/acre. This includes a total cost of $125 for seeds, $444 for Nitrogen, Phosphorous, Potash and lime application, and $35 for labor per acre. Cost associated with land could either be variable or fixed, and since it varies significantly from county to county and from region to region, and depends on whether it is irrigated or non-irrigated, it is not included in this budget. Land owners still accrue a cost associated with their land, which could be the market price they will pay for renting the land during the production season.

Table 1: Pre-Harvest Variable Costs of Producing Sweet Corn for Spring Fresh Market in Georgia, 2011.

Item	Unit	Quantity	Price	Amt/acre	Total
PreHarvest Costs					
Seed	Th	25.00	5.00	125.00	125
Lime, applied	Ton	0.50	30.00	15.00	15
Nitrogen	LB	300.00	0.60	180.00	180
Phophorus	Lb.	70.00	0.70	49.00	49
Potash	Lb.	250.00	0.80	200.00	200
Fungicide	Acre	1.00	5.50	5.50	6
Insecticide soil	lb	8.00	1.90	15.20	15
Insecticide	Appl.	25.00	7.12	178.00	178
Aerial Application	Appl.	25.00	4.00	100.00	100
Herbicide	Acre	1.00	10.00	10.00	10
Scouting & Inspection fees	Acre	1.00	19.50	19.50	20
Fuel, Oil & Machinery	Acre	1.00	25.00	25.00	25
Labor, Pre-harvest	Acre	1.00	35.00	35.00	35
Repair and Maintenance	Acre	1.00	25.00	25.00	25
Crop Insurance	Acre	1.00	21.00	21.00	21
Irrigation	Appl.	12.00	8.00	96.00	96
Interest on Operating Capital	$	1099.20	0.07	38.47	38
Total Pre-Harvest Variable Costs				1137.67	1,138

Harvesting and Marketing Costs

Harvesting and marketing variable costs include picking, grading and packing, pre-cooling, packaging and marketing. The cost was computed based on the average yield of 400 crates per acre, which it is assumed the grower can obtain 50% of the time (Fonsah et al., 2007; Fonsah et al., 2008; and Fonsah and Hudgins, 2007). The total variable cost for harvesting and marketing is $1,980 per acre. This includes $632 for labor, harvest, equipment and packing, $520 for pre-cooling, $688 for containers and $140 for marketing. This gives a grand total variable cost (pre-harvest, harvesting and marketing) of $3,118.

Table 2: Harvesting and Marketing costs of Producing Spring Fresh Market Sweet Corn in Georgia, 2011.

Items	Unit	Quantity	Price	$Amt/Ac
Harvest and Marketing Cost				
Labor, Harvest, equipment & Pack	Crate	400	1.58	632.00
Pre-cooling	Crate	400	1.30	520.00
Container	Crate	400	1.72	688.00
Marketing	Crate	400	0.35	140.00
Total Harvest and Marketing Costs			**4.95**	**1980.00**
Total Variable Costs[1]				**3117.67**
[1]Total variable costs = pre-harvesting cost + harvesting and marketing cost				

Fixed Costs

Fixed costs generally refer to items such as heavy machinery whose amount does not vary with the quantity of sweet corn produced. Some fixed cost items in sweet corn production include equipment ownership (depreciation, interest, insurance and taxes), management and general overhead costs. Overhead and management costs reflect 15% of total pre-harvesting variable or operation costs, which cannot be allocated to any one specific enterprise. Overhead items include utilities, pick-up trucks, farm shop and equipment, and fees. Most of these costs are incurred even if little production takes place and these costs should be considered when planning production costs (Fonsah and Hudgins, 2007; Fonsah et al., 2007; and Fonsah et. al., 2008; Bryd et al., 2006). Total fixed costs for producing sweet corn for the fresh spring market is $329 per acre and include costs for machinery ($58), irrigation ($100), and overhead and management ($171). Irrigation cost is not the cost of running the system on a daily basis (that is variable cost), but rather one-time investments such as cost of installing the irrigation system. Also note that machinery cost includes costs for tractor, plow, disc, herbicide applicator, planter, cultivator and sprayer. All calculation includes salvage value, equipment life-span, depreciation, interest, taxes and insurance.

Table 3: Fixed Costs of Producing Spring Fresh Market Sweet Corn in Georgia, 2011.

Items	Unit	Quantity	Price	$Amt/Ac
Machinery	Acre	1.00	57.72	57.72
Irrigation	Acre	1.00	100.00	100.00
Overhead and Management	$	1137.67	0.15	170.65
Total Fixed Costs				328.37
Total budgeted cost per acre				3446.04

Break-Even (BE) Cost of Production

As depicted in Table 4, the total break-even (BE) cost per crate of producing spring fresh market sweet corn is $8.62. This includes BE costs of $2.84 for pre-harvest variables, $4.95 for harvest and marketing and a BE fixed cost of $0.82 per crate. The results in Table 4 also reveal that growers need to produce more than 345 crates of sweet corn per acre in order to make a profit. Note that the BE pre-harvesting variable and fixed costs of producing sweet corn decreases with increase in yields.

Table 4: Break-Even Costs/Crate of Producing Spring Fresh Market Sweet Corn in Georgia, 2011.

Items	$Amount
BE Pre-harvest variable cost per crate	2.84
BE Harvest & marketing cost per crate	4.95
BE Fixed Costs Per Crate	0.82
BE Total budgeted cost per crate	8.62
BE Yield per Acre (crates)	345

Risk-Rated Net Returns

Like many agricultural products, sweet corn yields and prices vary from year to year. The volatility in yields and thus prices can be attributed to differences in adopted agricultural practices, pest and disease incidence, drought and torrential rain, etc. These annual variations in yields and prices are risk factors in sweet corn production in Georgia. In an attempt to account for the level of risk involved, the Extension Agricultural Economics Department uses five different measures of yields and prices (best, optimistic, median, pessimistic and worst), each reflecting how risky it is. This is shown in Table 5. In the best scenario, the grower can get 500 crates per acre and a price of $14 per crate. In the worst case scenario, s/he could get 300 crates per acre and/or a selling price of $6 per crate. This does not imply that when the grower obtains the worst yield he/she also obtains the worst price. It simply means that it is possible for a grower to get 300 crates/boxes per acre at time or a low price of $6 per crate when market conditions are unfavorable. The median values indicate that the grower should anticipate exceeding yields of 400 crates per acre and prices at $10 per crate half the time (Fonsah and Hudgins, 2007; Fonsah et al., 2007 and Fonsah et. al., 2008; Fonsah et al., 2009). On the other hand, optimistic values are those prices and yields sweet corn growers would expect to reach or exceed once every six years. Finally, the pessimistic values are poor prices and yields that would be expected once every six years. The best and worst values are those extreme levels that would occur once in a lifetime (1 in 49 years).

Table 5: Risk Rated Yields/Acre and Prices/Crate of Producing Spring Fresh Market Sweet Corn in Georgia, 2011.

Items	Best	Optimistic	Median	Pessimistic	Worst
Yield (crates)	500	450	400	350	300
Price (+cooling) per crate	$14.00	$12.00	$10.00	$8.00	$6.00

Risk-Rated Returns over Total Costs

The risk-rated returns over total cost of producing sweet corn in Georgia (Table 6) shows that in a best-case scenario, growers make at least $1,812 in returns and in the worst case, they lose $-704 or more 7% of the time. In an optimistic situation, a grower's return is at least $1,393 while in a pessimistic case, the loss in returns is at least $-285 16% of the time. Also, 50% of the time growers can expect returns of $554 or more. Moreover, the risk-rated returns show that 50% of the time growers earn a base-budgeted net revenue of $554 with a 75% chance of making profits.

Table 6: Risk Rated Returns Over Total Costs of Producing Spring Fresh Market Sweet Corn in Georgia, 2011.

Net return levels (TOP ROW);
The chances of obtaining this level or more (MIDDLE ROW); and
The chances of obtaining this level or less (BOTTOM ROW).

	Best	Optimistic		Expected	Pessimistic		Worst
Returns($)	1,812	1,393	973	554	135	-285	-704
Chances (%)	7%	16%	31%	50%			
Chances (%)				50%	31%	16%	7%
Chances for Profit		**75%**	**Base Budgeted Net Revenue**				**$554**

Budget Uses

An enterprise budget for sweet corn has multiple uses, besides its main use for estimating the total costs and break-even costs for producing sweet corn. The estimation of cash costs (out-of-pocket expenses) is important as it reveals how much money is needed to successfully carry out the project from start to finish from both the agronomic and marketing perspectives. It also provides commercial sweet corn producers with the tools needed for correctly planning strategic expansion of their enterprise. Moreso, it provides information on how much a grower needs to borrow from a financial institution. It is also important as it assists growers in preparing cash flow statements.

Conclusion

Estimating cost of production is an important aspect of risk management. It is important for growers of any commercial vegetables to know whether their enterprise is profitable or not. This information is pertinent to growers for sound decision making. This aspect of risk management is also applicable to sweet corn growers who can use enterprise budgets to determine the lucrativeness of their business. A risk-rated enterprise budget for sweet corn depicts that a grower in Georgia may earn a net return of $1,812/acre of sweet corn 7% of the time, $1.393/acre 16% of the time and as low as $554/acre 50% of the time. Also, this study reveals that there is a 75% chance of obtaining a profitable margin in sweet corn production.

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Organic Production

George Boyhan, Extension Horticulturist - Vegetables

Sweet corn can be grown organically, but this can be challenging because of high fertilizer requirements. Sweet corn should be grown in a planned crop rotation, and it is highly recommended that a legume crop immediately precede planting. Legumes fix nitrogen and can be an important source of this nutrient in organic production.

For specific information on certified organic production refer to the National Organic Program (NOP) or your local county Extension agent. The rules for certified production and a list of certifying agents are available from the USDA NOP website (http://www.ams.usda.gov/AMSv1.0).

Soil testing, even though it gives recommendations in inorganic fertilizers, can be an important part of planning your fertility program. Refer to Extension Circular 853 'How to Convert an Inorganic Fertilizer Recommendation to an Organic One' to see how to use this information.

For information on potential diseases and insects that may affect sweet corn, refer to the insect and disease sections elsewhere in this publication. Under certified organic production the use of inorganic chemicals to control these potential problems is generally prohibited. There are many cultural and management strategies that can be employed to help control these problems. For a general discussion on organic production and managing insects and diseases see Extension Bulletin 1300, 'Commercial Organic Vegetable Production'.

Probably the most difficult problem to manage under organic conditions is weeds, and variety of management strategies should be employed, including cover crops, soil solarization, stale seedbed, cultivation, plant spacing and mulches. Not all weed control methods will be completely effective; therefore, a number of methods may be necessary. Some weeds may be particularly difficult or impossible to control, such as nutsedge or bermudagrass, in which case a different location may be advised.

The organic market is particularly interested in different or unusual food sources. Along with standard commercial sweet corn varieties, there are a number of varieties that may be particularly desirable for organic markets. Both heirloom and colored varieties are available that growers may wish to grow. Growers wishing to grow such varieties should consult their buyers and make small plantings until they are comfortable with their performance.

Organic growers are more apt to save and share seed; however, many sweet corn varieties are hybrids. Hybrids will not come true-to-type when seed is saved and growers may be disappointed with subsequent generations.

Learning for Life

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