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PRODUCTION AND HANDLING OF SWEET POTATOES IN TEXAS

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INTRODUCTION

World-wide production of sweet potatoes is nearly 40 million acres. The United States produces over 200 thousand acres of this crop. Ten thousand acres of sweet potatoes in Texas have an annual value of over 14 million dollars. Over 80 percent of the Texas acreage is grown in the northeast part of the state. Sweet potatoes, when produced under the long growing season of the Southern United States, produce higher yields and more food value per acre than any other cultivated crop, yet require lower energy inputs.

Sweet potatoes have an amazing potential for feeding people, are relatively resistant to attack by pests, and in general, produce high and dependable yields with a minimum of costly energy inputs such as fertilizer and pesticides compared to those needed for high yields of cereal grains. For example, more people can be fed from an acre of sweet potatoes than from an acre of rice and with much less energy input.

A balanced diet is more realistic and much preferred to the elusive perfect food and the sweet potato can contribute greatly to balancing a diet. A small eight-ounce sweet potato provides 225 calories, about the same as a packaged diet breakfast and nearly one-fifth of the adult minimum protein needs. A recent National Nutritional Survey suggests that many American diets are low or borderline with respect to vitamin A. This same small sweet potato will supply vitamin A requirements for four days. It also contains twice the vitamin C required and enough iron for a woman for two and one-half days. Sweet potatoes contain most of the amino acids; they are low in tryptophane but have a high lysine content.

About 60 to 70 percent of the annual sweet potato crop is used as human food. About 5 percent of the crop must be retained for "seed" (plant-producing) purposes. The remaining 25 to 35 percent of the potatoes are lost through disease or shrinkage either at the farm or during preparation and marketing of the fresh or processed products or are used in small amounts for animal feeding or for industrial purposes.

The water and mineral absorbing root system of the sweet potato is more or less fibrous and is relatively extensive both in depth and in lateral spread. Although early investigators considered the edible sweet potato to be a tuber or thickened, modified underground stem, more recent anatomical studies of the developing young sweet potato have proved conclusively that this is a fleshy, thickened root.

Sweet potatoes are classified into moist and dry types. The moist are known popularly as "yams" and the dry as "sweet potatoes" although both belong to the same species in the morning-glory family. Both the Jewel and Centennial varieties grown in Texas are "yam" type sweet potatoes.

SOIL TYPES AND REACTION

Sweet potatoes may be grown on a wide variety of soils but production of high-quality roots with desirable sizes, shapes, appearance, and yields is best on fertile, well-drained, moderately deep, friable, fine sandy loams, sandy loams, and loamy fine sands underlain by firm, friable heavier subsoils such as clay loams or sandy clay loams. Sweet potatoes will grow at soil reactions ranging from about pH 4.5 to pH 7.5. Optimum yields and plant growth are usually best where the soil reaction ranges from about pH 5.6 to 6.5.

LAND PREPARATION

Since sweet potato planting and cultural operations are now mechanized, all plant residues from preceding crops must be chopped up and adequately incorporated into the soil during plowing and disking. Land should be plowed 6 to 7 inches deep when the soil is sufficiently dry to pulverize well. Allowances should be made for decomposition of cover crop or other plant residues before planting time.

Land preparation may involve incorporation of chemicals for control of nematodes, insects, and weeds. Nematicides cleared for use on sweet potatoes are listed in Table 1. The granular materials, fensulfothion (Dasanit) and ethoprop (Mocap), kill by contact and therefore must be mixed well in the soil for maximum effectiveness. Dasanit is effective for about six weeks when properly applied. Aldicarb (Temik) is a systemic material but still requires proper mixing in the soil. The other nematicides listed are liquid and cannot be applied at planting as can the granular nematicides. Plant injury will occur if an adequate waiting period is not allowed between treatment and planting.

Table 1. Nematicides for sweet potatoes.

Material (Trade Name)	Active Ingredient (Common Name)
DD	dichloropropene - dichloropropene mixture
Telone	dichloropropene
Terr-o-cide	ethylene dibromide
Mocap	ethoprop
Dasanit	fensulfothion
Temik	aldicarb

Sweet potatoes are grown on beds. Soil texture and the amount and intensity of rainfall are important factors determining the best bed height to use. On heavy soils in areas where rainfall may be heavy and drainage slow, beds 12 to 15 inches high are often needed. On light sandy loams, somewhat lower beds averaging about 10 inches high may be adequate. On light sandy soils use a bed height of 8 inches or less to allow excess water to drain from developing roots.

Fertilizer may be applied at or up to 2 weeks before planting time. For most producing areas, the fertilizer is applied before or at the time that the planting beds are constructed. Methods of applying and placing fertilizers and of constructing the beds vary somewhat in different producing areas and with the type and power of equipment available. To a large extent, single- or multiple-row, tractor-mounted applicators apply fertilizer at desired rates and placements, mix it with the soil, and construct beds uniformly and to the desired heights, often in a single operation.

FERTILIZER RATES AND PLACEMENT

Sweet potatoes are one of the more heavily fertilized vegetable crops. Analysis of both soils and plants in numerous studies indicate that approximately 50 pounds of N, 100 pounds of P_2O_5, 150 pounds of K_2O, 67 pounds of CaO, 30 pounds of MgO, and smaller quantities of S, Fe, Mn, Cu, Zn, B, and Mo are needed to produce a 700-bushel per acre commercial crop of sweet potatoes. Although this crop requires large amounts of commercial fertilizer, it is also highly sensitive to fertilizer injury and requires correct fertilizer placement.

Many tests have been conducted on the time, placement and methods of application of fertilizers for sweet potatoes. Results were usually best when the fertilizer was applied before planting and placed a few inches to the sides of the center line of the bed and on a level with or a little below the depth at which the plants were set. Specific advice for fertilization should be obtained from the local county Extension agent or Texas Agricultural Experiment Station.

CROP ROTATION

Crop rotation should be practiced since it has been shown that growing sweet potatoes on the same soil reduces the yield of quality marketable roots. Sweet potatoes should not be planted on the same land more often than once in 3 or 4 years.

VARIETIES

Of some 40 distinct varieties of sweet potatoes grown commercially in the United States in 1920 only two or three, or selected strains of those two or three, furnish an appreciable part of the current sweet potato supply.

For the past 40 years the National Sweet Potato Collaborators Group composed of research workers from state experiment stations and the United States Department of Agriculture from all regions of the country where sweet potatoes are grown have conducted intensive plant breeding programs to develop disease, nematode and insect resistant varieties of sweet potatoes with good horticultural characteristics such as root size, shape and desirable skin and flesh color plus good storage capabilities and high sprout production.

Two leading commercial varieties released after testing by the National Sweet Potato Collaborators Group are the following:

Jewel - Fresh market and processing. Moist-flesh type. Roots tapered to cylindrical, medium to large, orange skin and deep-orange flesh. Good quality. Vines green, vigorous, thick, long, trailing. Heavy yielder. Stores well. Fair sprout producer. Resistant to stem rot; intermediate to resistant to internal cork and root-knot nematode; susceptible to black rot, scurf and physiological breakdown from wet and/or field chilling (soil temperature below 55°F).

Centennial - Fresh market and processing. Moist-flesh type. Roots variably tapered to cylindrical, sometimes long, medium to large, orange skin and deep-orange flesh. Good quality. Vines vigorous, thick, long, trailing, reddish-purple except green at terminal ends. Leaves large, entire to lightly toothed, light-green. Very prolific, heavy yielder. Stores well. Only fair sprout producer. Moderately susceptible to stem rot and internal cork; susceptible to black rot, scurf, soil rot, and root-knot nematodes.

PLANT PRODUCTION

Sweet potato plants are propagated from "seed" roots which, when placed in warm plant beds, produce slips (also called sprouts, plants, or transplants). The greatest single cost of producing a crop of sweet potatoes is that of producing and transplanting the slips.

Selecting and Storing Seed Stock

Fields planted for production of sweet potato seed stock (bedding roots) should be grown from vine cuttings to minimize the amount and possibility of spread of diseases.

Seed stock should be dug and selected during warm, sunny, dry weather. It should be handled carefully to avoid unnecessary bruising or skinning, placed in clean containers, then transported promptly to a clean storage house, and properly cured and stored. Roots should not be injured by unnecessary handling once they are placed in storage.

Upon removal from storage, sort seed stock to eliminate all roots that show evidences of disease, undesirable flesh and skin mutations, or that do not have a bright, smooth firm external appearance.

Effective disease control starts with selection of a "clean" nematode-free bedding site. Select only healthy seed roots free of scurf and other obvious disease symptoms. Before bedding, treat seed roots of both seed and tablestock with an approved fungicide spray or dip of thiabendazole (Mertect®) to control unseen disease organisms present on root surfaces. Manufacturer's directions should always be followed.

Plant Beds

Plant beds, whether temporary or permanent, should be conveniently located on well-drained sites where there is no danger of contamination by water draining off higher lying, disease-infested land. Sites with *southern* exposure and some wind protection are desirable. The sandy soil used in plant beds should be in or obtained from a field or other source where sweet potatoes have never been grown or have not been grown for at least 4 or 5 years, and from a field or some other source that is free of possible contamination by diseases.

A good source of water is essential to the location of a good plant bed. About 15 square feet of plant bed space per bushel of medium-size roots bedded are required for all types of plant beds.

As a general guide, a good sprouting variety may be expected to produce, in the first one to two pullings, up to 1,000 plants per bushel of good-quality, medium-size seed roots bedded. For later plantings about 500 additional plants per bushel can be expected from each of one or two later pullings spaced at 7- to 10-day intervals.

Abundant supplies of early sprouts are especially important for plantings made in intensive culture areas having relatively short growing seasons. In such locations planting at earliest safe dates is imperative for high yields. This means bedding sufficient roots to supply the desired plants at one early pulling. A delay of only 10 days to 2 weeks in planting, occasioned by waiting for sprouts to develop for second or third pullings, can mean differences in marketable yields of 20 to 100 or more bushels per acre for each planting delay. Small to medium-size bedding roots produce more plants per bushel of bedded stock than do larger roots.

In preparing open field beds, plow and thoroughly prepare the bedding area, then rake, drag, or otherwise smooth and level the land into beds 4 to 6 feet wide and as long as desired. Proper drainage must be provided.

Most plant beds are established during March. Under favorable propagating conditions about 5 weeks are required from the time of bedding to produce suitable plants. Arrange seed potatoes in the beds as closely as possible without touching, spray or dip with fungicide, then cover roots with moist soil to a depth of 1 inch. Black polyethylene plastic placed directly on the surface of the bed, kept in place by soil plowed over the edges, has definite advantages for open beds. It can aid in maintenance of desirable temperatures by reducing loss of supplemental heat and by increasing the absorption of solar heat. It holds the desired amount of moisture in the soil while keeping excess moisture out. Put this cover over the bed immediately after bedding and remove it when the plants start to emerge. Complete sealing out of air with the plastic must be avoided. An additional 1" to 1½" of moist soil may be added to the beds as the slips emerge.

Optimum soil temperatures for sprout development are 75° to 85°F. Add only enough water to moisten the soil a little below the depth of the potatoes.

Since some slips reach the transplanting stage ahead of others, it is necessary to harvest plants from the beds 2 or 3 times. Water the bed, then remove the plants that are ready using a side pull rather than a straight upward jerk. Do not disturb the immature plants and the seed roots more than necessary. If you pull several plants in a bunch, separate them so that transplanting will not be slowed down. <u>Discard any cull plants at the time of pulling</u>. Finally, water the bed again to settle the soil.

<u>Presprouting</u>

In part, low plant production of some varieties has been overcome by presprouting the roots before putting them in the bed. The greatest benefit from presprouting is obtained with the slow plant-producing varieties. "Seed" requirements may be reduced about 1/3 with good presprouting.

Usually presprouting is started about 4 weeks before bedding by raising the temperature of the seed roots to about 85°F with a high relative humidity and maintaining such conditions until the roots show signs of sprouting activity before bedding. Some ventilation is desirable because the roots respire rapidly when the temperature is raised. Presprouted roots produce more early plants, than roots not presprouted.

FIELD PLANTING

The number of plants required per acre varies with the spacings used within and between rows. For average recommended spacings of 12 to 15 inches in the row and about 3½ feet between rows, roughly 10,000 to 12,000 plants are needed for setting one acre. This number may vary with time of planting, fertilizer and moisture availability, and date of harvest.

Transplant slips to clean fields where other crops not affected by sweet potato diseases have been grown for at least 3 years. Where stem rot or wilt has occurred previously, use wilt resistant varieties such as Jewel or Centennial. The Jewel variety also has some resistance to the rootknot nematode.

Sweet potatoes are set in the field either by hand or with machines. Machine transplanters not only save man labor but also transplant the plants more uniformly and generally more satisfactorily than hand setting. The machines are equipped with watering devices that apply a small quantity of water around each plant just before the soil is drawn around it. Under some conditions rapid recovery of plants following transplanting is facilitated when dilute "starter" nutrient solutions are used instead of plain water. High-analysis, soluble starter fertilizers are available commercially for use at 1-3 lbs/50 gals. of water.

Three workers with a one-row planter can set 3,500 to 4,000 plants per hour--one worker driving and two workers handling plants. With a two-row planter, five workers can set 7,000 to 8,000 plants per hour. If the soil is moist enough for setting the plants without water, considerably larger numbers can be set per hour because stops for filling the water tanks are unnecessary.

For efficient results with machine transplanters, the work crews must have experience and skill, the field must be well prepared, the water tanks must be refilled quickly, and the plants must be of medium size and neatly arranged for rapid handling.

Best plants for field setting of most varieties should average about 8-9 inches long (including the rooted parts of the plants). Sturdy, thick-bodied, disease-free plants ranging from about 7 inches to 10 inches long and each having 6 to 8 leaves handle best in transplanting, establish well, and give best stands and overall production.

Highest total and marketable yields are obtained from plantings made as plants become available in the spring and the average soil temperature is 60°F or above after the frost-free date for that particular area. Delay in planting reduces both the total crop yields and the yields of prime market-size potatoes unless irrigation water is provided.

WEED CONTROL

Herbicides are generally used on sweet potatoes to control weeds early in the season to reduce the amount of cultivation needed and to maintain weed control after the lay-by cultivation with a minimum expenditure for hand labor. Herbicides are usually used in combination with mechanical cultivation operations for weeding, bedding and fertilizing the crop. Herbicides used under favorable conditions immediately after transplanting will control weeds throughout the growing season with supplemental cultivation. Amiben, Dacthal, and Eptam herbicides are available for control of weeds in sweet potatoes. These chemicals and others are used successfully in field practice. Texas Agricultural Experiment Station scientists, Texas Agricultural Extension Service specialists and County Extension Agents can help the grower select herbicides and methods of use that have proved most successful for local conditions. All precautions for storage and use of herbicides should be carefully observed.

WATER REQUIREMENTS AND IRRIGATION

The sweet potato is not a dry-weather crop although it may be considered as a moderately drought-tolerant one. The most severe yield reductions result from prolonged water shortages 35 to 50 days after planting, when vine elongation is slowing down and storage root initiation has begun. Yield reductions are less severe when droughty periods occur either a little earlier or a little later than this. Drought reduces the number of storage roots more than it reduces their size if a dry period occurs when root formation begins.

Highest yields of best quality sweet potatoes can be expected only where the crop is planted in sufficiently moist soil and where adequate supplies of soil moisture are maintained throughout the growing season up to about 2 or 3 weeks before harvest. Approximately 18 to 24 inches of water, well distributed throughout the growing season, supplied by rainfall or by irrigation or by rainfall supplemented by timely irrigation, are needed for best sweet potato production. Irrigation water is usually supplied by overhead sprinkler systems.

HARVESTING THE CROP

Someone has said that for the best quality sweet potatoes the roots should be handled "like eggs". The amount of handling can be lessened if the grower will at least partly grade the crop in the field by putting the roots of separate grades directly into the baskets or crates in which they will be stored or marketed.

The usual steps in harvesting sweet potatoes are: (1) Vine cutting or removal; (2) digging, followed by packing the roots in field containers (usually with some selection for grade); (3) loading field containers and hauling them to the packing shed or storage house; and (4) either (a) grading and packing the roots preparatory to direct shipment to the fresh market or (b) placing them in the curing room preparatory to storage.

To further reduce the labor required for digging, sorting, and crating sweet potatoes, combine-type harvesters have been developed. On some of these machines the sweet potatoes are separated from the vines and placed in crates, bulk (½ ton) boxes, or bulk trucks directly from conveyors after digging. The filled crates are stacked temporarily on platforms located either at the side or at the rear of the harvester. Some platforms have been designed to hold one or two pallets on which the crates are stacked. The palletized crates are removed with a tractor-mounted forklift and placed onto a truck that hauls them to the storage house.

The time for harvesting sweet potatoes for storage usually is when the highest yields of No. 1 grade roots can be expected for the particular field and harvesting can be completed before the time frost injures the vines. Usually 130 to 150 days from planting are needed to give best yields. Chilling injury to all roots occurs as the soil temperature drops to 55°F or lower.

The greatest danger from delayed digging, however, is in the effect that wet soil has on the roots. Excessive moisture in the soil, either before or after frost injures the vines, causes physiological changes in the roots. Under such conditions, the roots cannot heal properly, and decay-producing organisms gain entrance into the roots. The Jewel variety is more susceptible to wet soil and/or field chilling than the Centennial variety.

The quality of sweet potatoes coming out of storage can be influenced by the kind and amount of injuries inflicted during harvesting and handling. Exposure of sweet potatoes to bright sun, chilling temperatures, or drying winds for periods sufficient to damage tissue makes healing more difficult and may result in considerable loss from decay.

After the storage house is emptied in the spring, all old or decayed sweet potatoes and other debris should be removed. False floors should be removed and cleaned underneath. The floor of the storage house should be flushed or swept. Any repairs that are needed should be made.

In the late summer and early fall the weather at harvest and shortly thereafter is often warm so no heat need be supplied to the storage to obtain temperatures approximating those needed for curing.

CURING AND STORAGE

The primary purpose of curing sweet potatoes is to keep them in good condition for marketing during the winter and spring and to preserve seed roots to be used in producing plants for the next crop.

Regardless of how carefully sweet potatoes are handled during harvesting, some wounding of the roots is inevitable. To prevent infection of wounds by disease-producing organisms, the roots are brought into storage as soon after digging as practical and are cured for 4 to 7 days at from 80° to 85°F and at 85- to 90-percent relative humidity. Under these conditions injuries are healed rapidly through the formation of new wound-cork layers beneath the wounded areas. Roots that have been properly cured usually have produced a few very short sprouts and have a somewhat velvety feel. The rate of healing is slower at temperatures below 85° or above 95°F and at relative humidities below 85 percent. During curing, sweet potatoes may lose up to 5 percent of their weight.

In addition to healing wounds, curing also speeds up those physiological changes that make the sweet potatoes more palatable after cooking. The major change involves the conversion of starch to sugars and dextrins.

After curing, sweet potatoes should be held at 55° to 60°F with a relative humidity of 85 to 90 percent. Ventilation is required. Fresh air should be introduced at a rate equal to the cubic-foot capacity of the storage every 2 hours to prevent the accumulation of carbon dioxide. This is equivalent to 1 cfm/bu sweet potatoes.

Most weight loss is due to evaporation of moisture through the skin. In addition, sweet potatoes lose weight as a result of respiration that consumes some of the stored food in the root, primarily sugar and starch. During respiration, carbon dioxide and water are given off, thus decreasing the weight of the root. Loss of weight is encouraged by high storage temperature and low relative humidity. At 55° to 60°F and 85- to 90-percent relative humidity, properly cured sweet potatoes usually lose about 2 percent of their weight per month although differences exist among varieties.

One important aspect of the loss of weight from sweet potatoes is its association with the development of pithiness in the roots. Although sweet potatoes lose both weight and volume during curing, there is little change in volume during storage. Consequently, with loss of weight during storage the roots become pithy. When more than 12 percent of the volume of a root becomes intercellular space, pithiness can usually be seen by cutting the root in half. Obviously, then, weight losses should be kept to a minimum to retain good quality during storage.

The development of pithiness is accelerated by the same conditions that cause weight loss. High temperatures during storage increase respiration and sprouting of roots, thus increasing pithiness. Low relative humidities during storage also increase weight losses and accelerate development of the pithy condition.

At any time that temperature in storage rises above 60°F sprout growth will occur. Since heat and moisture often collect in the top of a storage room, excessive sprouting is most often noticed in the top layers of sweet potatoes. Sprout growth contributes to the development of pithiness.

SORTING AND GRADING FOR THE FRESH MARKET

Some injury to sweet potatoes is bound to occur during handling, washing, sorting, and grading as sweet potato roots are removed from storage for market. The bruised or crushed tissues offer favorable locations for decay to develop. Soft rot causes most decay but other diseases such as black rot, Java black rot, surface rot, and fusarium rot may also cause losses during marketing. To prevent or greatly reduce such losses, the sweet potatoes are treated with fungicides after washing and before the roots are graded and packed for market. One effective treatment is to thoroughly wet the roots with a solution of Botran fungicide.

INSECTS

Many insects feed on the roots of sweet potatoes. Roots are often attacked from the time they begin to enlarge in June or July until harvest in October or November. The large number of insects involved and their resistance to insecticides make their effective control by any one method unlikely. Therefore, the responsible species must be identified whenever possible.

Examine roots from several plants at frequent intervals during the growing season to learn what insects may be injuring a crop of sweet potatoes. If injury is found, search the surrounding soil and foliage for eggs, larvae, pupae or adults of the pest causing the injury. Adults of several species of beetles feed on sweet potato foliage, and their presence can often be detected by the type of leaf injury they cause.

Wireworms

Several kinds of wireworms feed on sweet potatoes. The southern potato wireworm (Conoderus falli) is probably the most injurious. The adult beetles are dark brown, about a quarter of an inch long and are found near the soil surface under leaves and trash in sweet potato plantings. The adults do not feed on sweet potato plants.

Sweet potatoes are injured by the larvae, which hatch from eggs laid in the soil during the summer and early fall. The larvae are white, cream, or yellowish gray with reddish-brown heads and tails. The are smooth, shiny, and relatively hard-bodied.

Injury by southern potato wireworm larvae usually consists of fairly small irregularly shaped holes. If growth cracks or other breaks in the skin are present, injury may be concentrated in this area. Otherwise, the injury may be scattered at random over the surface of the root. The original holes are usually less than a quarter inch deep and seldom as much as a half inch but may be considerably deepened by later growth of the root. New feeding holes have ragged edges and usually contain chewed root fiber. This is a good diagnostic character.

Cucumber beetles

Larvae of the banded cucumber beetle (Diabrotica balteata) and the spotted cucumber beetle (D. undecimpunctata Lowardi) often feed on roots of sweet potatoes. The spotted cucumber beetle occurs east of the Rocky Mountains wherever sweet potatoes are grown. The banded cucumber beetle has become a major pest of the sweet potatoes in southern Louisiana. It is abundant from coastal South Carolina southward into Florida and westward along the Gulf Coast to Texas and also occurs in California.

Cucumber beetle larvae eat small round holes through the skin of sweet potato roots, and form irregularly-shaped enlarged cavities just under the skin. The feeding scars are usually in groups rather than scattered randomly over the root. The original holes are usually shallow but may be deepened by later growth of the root. In contrast to wireworms, cucumber beetles often attack sweet potatoes early in the season. This results in much injury.

Flea beetles

The elongate flea beetle, *Systena elongata*, the pale-striped flea beetle, *S. blanda* and *S. frontalis*, feed on sweet potatoes. One or more of these species probably occur wherever sweet potatoes are grown.

Adults of the elongate flea beetle are about one-eighth inch long and black with longitudinal white stripes on their backs. They produce characteristic feeding scars on the upper surface of sweet potato leaves. Unlike the pale-striped flea beetle, they usually do not chew entirely through the leaf unless it is young and tender. Adults of the pale-striped flea beetle are very similar to adults of the elongate flea beetle except that legs, head, and thorax of the pale-striped flea beetle are usually not quite as dark. They feed on sweet potato leaves and make irregular holes which are smaller than those made by cucumber beetles. *S. frontalis* adults are usually a little larger than the other two beetles and have no white stripes on their back. They also eat small holes in the leaves.

The habits and life histories of the three species are similar, and the immature stages look alike. These insects have a wide range of hosts including many weeds. Adults move into sweet potato fields during the spring and summer and lay cream to yellow eggs in the soil. After a week to 10 days these hatch into white larvae which later become pale yellow to pale salmon depending on their food. The larvae are soft bodied and about three-eighths of an inch long when full grown. They have brown heads and a fleshy pointed tubercle on the tail end. The larvae mature in 20 to 30 days, then curl up in a cell made in the soil and transform into pupae. The adults emerge in about 1 week. Probably at least two generations occur a year in the South.

Systena larvae eat small holes through the skin of sweet potatoes and make enlarged cavities and short tunnels just under the skin. Except for these tunnels *Systena* injury is very similar to that of cucumber beetle larvae, which seldom tunnel into the roots. At harvest time early season *Systena* injury usually appears as shallow healed scars which tend to be elongate or irregularly shaped in contract with those of cucumber beetle larvae, which are usually round. In some soils, late-season *Systena* feeding results in a large number of small shallow holes in the roots. This is sometimes referred to as "pinhole" injury.

Sweet potato flea beetle

Adults of the sweet potato flea beetle, Chactocnema confinis have long been recognized as pests of sweet potato foliage, but the larval injury to the roots was reported only recently. This insect occurs almost everywhere that sweet potatoes are grown and lives on bindweed as well as sweet potatoes.

The adult beetles are black, about one-sixteenth inch long, and characteristically hop away when disturbed. They eat narrow channels or grooves in the upper surface of sweet potato leaves. This injury is quite characteristic and easily recognized.

The adults pass the winter in sheltered locations in hedgerows and the edges of woods. They move into sweet potato fields soon after planting. The eggs are laid in the soil and after a few days hatch into slender white larvae that are similar to Diabrotica and Systena larvae but have no dark spot or fleshy tubercle on their tail end. When fullgrown the larvae are about three-sixteenths of an inch long. They change into pupae in the soil. During the warmer months of the year the entire life cycle of the sweet potato flea beetle is completed in about 30 days. A succession of broods occurs during the spring, summer, and autumn.

Sweet potato flea beetle larvae make small winding tunnels just under the skin of sweet potato roots. These tunnels are nearly invisible at first but soon darken and can be seen through the skin. As the roots grow, the skin over the tunnels splits away leaving shallow scars on the surface. Although large larval populations of the sweet potato flea beetle are often found in sweet potato plantings, usually they cause little injury to the harvested roots. Apparently the larvae feed mostly on the fibrous roots and attack the enlarged roots only under certain conditions. Sweet potato varieties differ widely in their susceptibility to economic injury by this insect.

Sweet potato weevil

The sweet potato weevil (Cylas formicarius elegantulus) is a serious pest of sweet potatoes and occurs in certain parts of South Carolina, North Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas. Most damage from this pest is caused by the larvae. Some damage may be caused by the adult. This insect has been studied more thoroughly than any other insect pest of sweet potato roots.

Adult sweet potato weevils are ant-like beetles about a quarter of an inch long. The head and wing covers are metallic dark blue and the thorax and legs, bright orange red. The adult weevil feeds on any exposed part of the sweet potato plant but prefers the roots. Feeding scars on the roots consist of tiny shallow holes usually in patches.

Injury to sweet potatoes by weevil larvae can be recognized by tunnels that start just beneath the skin and become larger as they extend inward. The tunnels are much smaller but similar to other insect species that feed on sweet potatoes and frequently contain larvae, pupae, or newly transformed adults. Adult exit holes are about the size of a wooden match stem.

White grubs

Some white grub (Phyllophaga spp.) injury to sweet potatoes occurs. White grubs are the larvae of May or June beetles. Adults of the various grubs vary in size and color but all are robust beetles. Many of them are night flyers and frequently come to lights.

Grubs gouge broad shallow areas in sweet potato roots. Their injury is unlike that of any other insect except cutworms, but grub scars are much rougher and frequently shallower. Since grubs feed upside down, hortizontal roots are injured mostly on the under side.
