

KENTUCKY PUMPKIN
INTEGRATED PEST MANAGEMENT

GROWER MANUAL

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Kentucky Pumpkin Integrated Pest Management

The first pumpkins reported in Kentucky historical records were grown in 1779 on Captain Nathaniel Hart's farm about five miles south of what is now Richmond, Kentucky. There has recently been increased interest in pumpkin production in Kentucky primarily for the Halloween market and for ornamental decorative purposes. Pumpkins are a warm season vegetable and can be grown throughout the state. Pumpkin acreage varies year to year because the crop can be grown almost anywhere with only a small capital investment. Major production areas competing with Kentucky include: Illinois, Indiana, Ohio, Michigan, Pennsylvania and New York. One of the major considerations before producing any horticultural crop is to determine how and where it will be marketed (**see section on Yields, Marketing, and Returns**). There are approximately 1,000,000 family units (households) in Kentucky. If each household bought one pumpkin every year it would require about 500 acres (avg. yield 2000 pumpkins per acre) to supply the demand.

VARIETIES

Pumpkins vary greatly in size from the small miniature pumpkins weighing a pound or less to those weighing over 400 pounds. The 1000 pound record was recently obtained for the world's largest pumpkin (actually a type of winter squash!). Select varieties with disease resistance or tolerance whenever possible. The following varieties are well adapted to Kentucky conditions:

Large Size, 16 - 40 lb Range

Pankow's Field - 120 day maturity. A very high yielding hybrid variety. Fruit are dark orange with deep ribs and very heavy, strong, dark green stems. They average 14-16 lb and measure 9-10 inches in diameter.

Gold Rush - 120 day maturity. Extremely heavy yielding hybrid variety. This is a large round pumpkin (30-40 lb range) with a dark rind and thick flesh. The handle is 4 inches long and nearly 3 inches thick.

Gold Strike - 110 day hybrid in the 21 to 27 lb range, very productive, attractive pumpkin and stem.

Howden's Field - 115 day maturity. Large vines - fruit are deep orange color. An open pollinated variety. Average 17 - 20 lb and 14 inches in diameter. This has been an excellent performer in



Kentucky. **Moderately resistant to black rot.** However, Howden has been shown to be the most sensitive variety to female flower abortion under hot dry conditions in New York. Female flowers turn yellow, never open and drop off the vine. Photo courtesy of Ohio State University Extension.

Merlin (HMX 5680) - 115 day hybrid with powdery mildew tolerance. Fruits average 15 to 25 lb, are slightly upright, and have a deep orange color. Vines are large and vigorous. For trial.

ProGold 500 - 95 day maturity, averaged 16 tons/A and 15 lbs/fruit in 4 yrs of trial. Round to slightly upright. Medium orange with good handles. Consistent in yield and quality. Photo courtesy of Ohio State University Extension.



Pro Gold 510 - 95 day maturity, very attractive dark orange colored fruit, 22-26 lb, 12 to 16 inches in diameter. Excellent dark green (almost black) handle. Photo courtesy of Ohio State University Extension.



Aspen - 95 day hybrid with vigorous semi-bush vines. Fruit average 20-22 lb, are blocky, 11-12 inches in diameter and dark orange in color. The fruit stem is dark green and fairly strong but not as nice as Howden's.

Appalachian - 90 day hybrid. Fruit average 25 lb and are a dark orange. A semi-bush vine with limited runners to replace Happy Jack. Has high yields and pumpkins are very uniform with good handles. Photo courtesy of Ohio State University Extension.



Medium Size, 6 - 15 lb Range

Spookie - 110 day maturity, compact vines. 10 lb. size, 6-7 inch diameter, bright orange skin. Good for pies. An open pollinated variety.

Tom Fox - 110 day, 12 lb pumpkin. Dark orange color, well ribbed, slightly smaller than Howden. Was impressive for the size of its stems, which were almost twice the thickness of any other variety. Long vines, variety of shapes and heavy for its size.

Lumina - 110 day maturity, white pumpkin for carving and painting with a bright orange flesh. Fruit average 7 to 8 lb and 9 inches in diameter and the shape varies from globe to flat globe. Good for pies. Not a particularly high yielding variety and fruit scar easily. Harvest slightly immature to obtain a better white color, otherwise these can turn gray.

Jack of All Trades - 95 day hybrid ranging from 10-14 lb. Averages 12.8 lb, semibush Howden type. Bright orange with shallow ribs, very uniform, with a large dark green stem. Looked good in 1996 Illinois trials. Recommended for trial.

Rocket - 95 day, 12 lb pumpkin that is heavy for its size and **remains free of rot throughout the fall and display season.** Upright shape with distinctive shoulder ribbing and a medium orange color. Long strong green handles. Vigorous seedlings and vines.

Big Autumn - 90 day maturity. A high yielding hybrid variety with fruit averaging 13-15 lb and 10 inches in diameter. Fruit stems are strong and are an attractive dark green with a yellow base. The fruit are deep orange, very smooth and deeply ribbed. Good for a children's pick your own.

Magic Lantern (HMX 5683) - 12 lbs/fruit. Similar to Wizard and one of the first varieties available with powdery mildew tolerance. Slightly elongated, attractive, dark orange fruit on a semi-vine plant. Powdery mildew tolerance also helps to promote high quality fruit handles.



Small, 2 - 4 lb Range

Spooktacular - 95 day hybrid Baby Pam. Fruit are 3-5 lb, measure 5 X 6 inches and have a darker orange skin than Baby Pam. The skin is smooth with shallow ribs and fruit are very uniform in size. The stems are dark green and strong. Good for pies. Has performed well in Quicksand trials.

Baby Bear - 105 days, 1.5 lb, 5 inch diameter pumpkins. This variety **has good disease tolerance**, a 4 inch handle and was a 1993 AAS winner.

Oz - 105 day maturity, 2-4 lb, smooth dark orange fruit measuring 5-6 inches in diameter. Contains the precocious yellow gene and colors up early. They are very attractive and excellent for painting. Excellent handle on fruit. A semi-bush plant that yields well in a small space.

HMX 4696 (Ironsidies) - 10 tons/A, 2-3 lbs/fruit. Round, moderate orange color, tough hard shell, not for carving, but smooth skin is good for painting. Good keeper. Source: Harris. Photo courtesy of Ohio State University Extension.



Miniature, Ornamental

Jack Be Little - 95 day maturity, 0.40 lb, deeply ribbed orange fruit. Open pollinated; very productive, large vines.

Baby Boo - 95 day maturity, white 0.35 lb deeply ribbed fruit measuring 3-1/2 inches in diameter. Large vines are very productive.

Wee-Be-Little - 95 days, 0.5 lb, 3" diameter fruit, nice small pumpkin, 1999 All American Winner, bush type plant, for trial.

Extra Large (Exotic Type)

Atlantic Giant - 120 day maturity, pink-orange color, resistant to four races of Fusarium fruit rot. These have reached weights of over 600 lbs.

Burpee Prize Winner - 120 day maturity, 50-200 lbs, reddish orange, attractive, very large with shape and color superior to Atlantic Giant. Strong tan colored stem.

Big Moon - 120 day maturity, orange color, 40-200 lbs, a very large show pumpkin.

Unusual

Rouge Vif d'Etampes (Cinderella) - 115 day, 10-15 lb open pollinated variety. This is a French variety that is actually a squash. It is redish orange, very flattened and deeply ridged. Suitable for pumpkin pie.

Jarrahdale - 100 days, 6-10 lb. Drum shaped with heavy rounded ribs, slate grey skin and good quality orange flesh.

FIELD SELECTION AND PREPARATION

Crop rotation is an important consideration when growing pumpkins as with any vegetable crop. Most problems with pumpkins are caused by diseases that affect foliage and fruit. Disease control must start before planting. Select land that has not been in pumpkins, other vine crops, peppers or tomatoes for at least three years. All of these crops are susceptible to some of the same diseases. Also be aware of the possibility of herbicide carry over from the previous crop. Sites with good air and water drainage also help reduce potential disease problems. Poorly drained, heavy soils or hardpan soils should be avoided. Sandy loam or clay loam soils, high in organic matter are very desirable.

Soil Preparation

Prepare a good seed bed by plowing deep. Avoid plowing when soil is too wet, which may result in a very cloddy condition and soil compaction. Weed control is more difficult in cloddy soil.

Fertilization

Pumpkins grow best with a soil pH of 5.5-6.8. Lime should be applied if soil pH is low. Manganese toxicity may occur at low pH levels. A soil test is recommended to determine phosphorus and potassium requirements. Pumpkins are also sensitive to low magnesium levels and a test for magnesium is also recommended. Pumpkins do well in a soil that has had 10-12 tons of well rotted manure applied or a good green manure crop plowed under.

Pumpkins will produce an excellent crop with an application of 75 to 80 pounds of N per acre (Table 1.). A sidedressing of 50 lbs actual nitrogen when vines begin to run will help maintain fruit size, especially on sandy or low fertility soils. Too much nitrogen reduces fruit set and quality.

Planting

Pumpkins are a warm season crop and do not do well until soil and air temperatures are above 60°F. Calculate the days to harvest to determine when to plant pumpkins for Halloween. It is usually best to aim for a mid to late September harvest date. Varieties maturing in 90-95 days should not be planted until early to mid June. Varieties that take 100 to 115 days to mature should be planted between late-May and early June. If planted too early pumpkins may rot before Halloween.

If planting by hand, plant three seed at each location in the row with five feet between each hill or group of seeds. Plant seed one to two inches deep. Some growers have successfully grown pumpkins using a no-till system by seeding into stubble of a rye or rye-legume cover crop that has been killed with a herbicide. This can eliminate the need for washing pumpkins prior to marketing, may reduce fruit rots, and makes for an easier/cleaner field to walk in for school children or "pumpkin festival" customers.

Table 1. Fertilization Based On Soil Test Results	
Phosphorus	
Soil Test Reading	Lbs. Phosphate (as P ₂ O ₃) Needed/A
Low - 30 lb/A or Less	180
Medium - 31-60 lb/A	120
High - 61-80 lb/A	60
Very High - Above 80 lb/A	0
Potassium	
Soil Test Reading	Lbs Potash (K ₂ O) Needed/A
Low- 200 or Less	300
Medium - 201-300	200
High - 301-450	100
Very High - above 450	50
Nitrogen	
Comments: Apply 75-80lb actual nitrogen (N)/A broadcast before planting. Apply 100 lb N/A if sod was plowed down. Sidedress with an additional 50 lb N/A when vines begin to run. Reduce N application when manure is used; excess N may reduce fruit quality.	

Large-Vining types should be seeded in rows 9 to 12 feet apart. If seeding mechanically, thin plants to 40 - 60 inches between plants.

Semi-Vining types can be grown in rows eight feet apart with plants spaced four feet apart in the row. Thin to two plants per hill in the row.

Bush types should be planted in rows six feet apart with single plants every three feet in the row. Miniature pumpkins are normally planted 40 to 60 inches apart in rows which are 6 feet to 8 feet apart.

Two to three pounds of seed are generally required to plant an acre when seeding with planters. Slightly less seed will be needed if they are seeded by hand. A Planet Jr. seeder or hand pushed garden seeder can be used very successfully. Since the price of hybrid seed is much higher than for open pollinated seed, it may be desirable to hand plant hybrid seed. Pumpkin seed may decay if planted in cold wet soil so always plant fungicide treated seed.

Weed Control

Vegetable crop weed management can be a difficult issue for producers for many reasons. First, vegetable crops are high value crops which have limited options available for full-season weed management. Weed control can be complex due to the long-season requirements for many crops. The

chemical industry has recently focused upon development of new, selective chemistry mainly in large acreage agronomic crops to maximize profitability. New product development in vegetables is limited due to comparatively small acreage production of vegetables leading to reduced potential profitability and problems of liability associated with high-value horticultural commodities. The mandated reregistration of herbicide products and FQPA (Food Quality and Protection Act) have contributed to actual reductions in numbers of labeled products due to increased and excessive expenses associated with reregistration or problems with product safety and mammalian health. Finally, non-chemical control options can also be limited due to the nature of crop production and the planting density. For example, repeated tillage or cultivation to control weeds in pumpkins would be difficult and detrimental to the crop due to the vining nature of the crop and its shallow root system which is easily damaged through close cultivation.

Weed Control Strategies - Weed management in vegetable crops tends to be exceptionally difficult for several reasons.

the nature of several of the crops: if direct seeded, slow growing, and non-competitive.

the sensitivity of certain vegetables to herbicide injury (non-tolerant).

the high value of the crop and its long growing season create difficulties for chemical industry to assume liability for the problems encountered.

the lack of labeled chemical controls for this crop due to problems with reregistration of herbicides, lack of interest in the chemical industry to create labels for minor use commodities with smaller potential markets.

the potential for injury to crops by using repeated cultivations as the crop matures.

What is the solution? Use an INTEGRATED approach for control of weeds!

1) Choose a site appropriate for the production of vegetables and ensure that this site is as clean and weed free as possible before establishment. *Rotate your vegetable crop into a site that is as weed free as possible. Avoid planting into sites with residual herbicide carryover (areas where agronomic crops were produced, for example)

2) Use adequate cultural practices to prepare a good seed or transplant bed. Kill perennial weed problems. Use tillage and cultivation to control annual weeds. Pre-treat with Round-Up or Paraquat (non-selective, postemergence) to control perennials, or Poast and Fusilade (selective, postemergence) to control perennial grasses.

3) Use mulching materials if cost effective for production of long-season crops. Black plastic for weed suppression is often used in melons and squashes, in combination with trickle irrigation. Weed management around holes in black plastic where the crop was established is necessary, as well as in row middles. Control is often difficult just next to the black plastic bed where weed escapes tend to emerge. Use of an incorporated preemergence product is suggested, followed by postemergence directed application next to the plastic to control the escapes.

4) Before planting, consider use of an effective preemergent herbicide (preemergent to the weed) which is selective (one that the crop tolerates). Apply in dry, non-windy conditions and cultivate to incorporate if required. Most preemergence herbicides will control certain grass and broadleaf weeds for a period of 4 to 8 weeks. After weed escapes are observed, utilize a postemergence herbicide for grass control. Also cultivate if possible to reduce weeds later in the season. Once a preemergence soil applied herbicide is used, it is better not to disturb the soil surface for as long as possible to maximize control.

Common preemergence herbicides for vegetable crops: Treflan, Command, Goal, Dual, Sencor, Lasso, Curbit, and Devrinol.

Common postemergence herbicides for use in vegetable crops: Round-Up, Paraquat, Poast, Fusilade, and Basagran.

For pumpkins, Prefar and Command are labeled for use in direct seeded pumpkins as well as transplants. Both herbicides must be shallowly incorporated after application. Curbit has a 24 C label in KY, IN and OH. Moisture is needed within 5 days of application for activation. Heavy rains may cause injury. Poast is labeled for postemergence control of grasses and has a 14 day PHI.

How to apply: Tractor mounted sprayer, Wick applicator, or Back pack sprayer.

Cover crops with Weed Suppressive Abilities - Cover crops are useful as a means to incorporate organic matter into the soil when turned under as green manures. Some also possess chemicals which aid in weed suppression. Green manures which are suppressive include the sorghums, buckwheat and mustards. Other cover crops are killed or harvested and the residue remains on the soil surface. This assists in preventing soil erosion, conserving soil moisture, and suppressing weeds. The residues can be highly weed suppressive due to their physical as well as chemical presence. These include wheat, rye, barley, oats, clovers, fescues, annual and perennial ryegrass. Legume cover crops such as vetch will also contribute nitrogen to the succeeding crop.

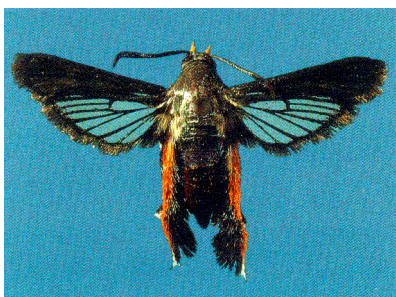
Pumpkins can be produced using no-tillage production techniques. Rye or wheat straw is suitable for pumpkins when the residue remains on the soil surface during the time of planting. A no-till seed drill is recommended for direct-seeded pumpkins. The cover crop can be killed with Round-Up, Paraquat or Poast herbicide. A preemergence herbicide application of Command, or Curbit can be applied to supplement weed suppression, followed by a postemergence application of Poast for grassy escapes. When a no-till seed drill is not available, growers rototill a narrow band down the row where the pumpkin seed or plants are to be planted. Water application may be necessary at seeding or transplanting in dry seasons with no-till production.

Irrigation

A source of supplemental water is beneficial for increasing yields most years in Kentucky. There will usually be a period of two to four weeks when plants are stressed from lack of adequate moisture. One to two inches of water each week during these droughty periods is very beneficial in increasing overall yields and fruit size.

INSECT CONTROL

Squash Vine Borer - The squash vine borer is a key pest of pumpkins in Kentucky. Unfortunately, it is usually noticed only after it has done its damage. Symptoms appear in mid-summer when a long runner or an entire plant wilts suddenly. Infested vines usually die beyond the point of attack. Sawdust-like frass near the base of the plant is the best evidence of squash vine borer activity. Careful examination will uncover yellow-brown excrement pushed out through holes in the side of the stem at the point of wilting. If the stem is split open, one to several borers are usually present. The caterpillars reach a length of 1 inch and have a brown head and a cream-colored body.



The adult squash vine borer is a stout dark gray moth with 'hairy' red hind legs, opaque front wings, and clear hind wings with dark veins. Unlike most moths, they fly about the plants during the daytime, appearing more like a paper wasp than a moth.

The insect overwinters as a full grown larva or a pupa one to two inches below the soil surface. If it has not already done so, the larva pupates in the spring. Adult moths begin to emerge about the time the plants begin to run, and moth flight continues through mid August.

The small brown eggs, laid individually on leaf stalks and vines, hatch in seven to 10 days. The newly hatched larva immediately borers into the stem. A larva feeds for 14 to 30 days before exiting the stem to pupate in the soil. There are 1 to 2 generations per year in Kentucky.

Management - The key to squash vine borer management is controlling the borers before they enter the stem. Once inside the vine, insecticidal control is ineffective. Poor timing of sprays is the usual cause of inadequate control. Monitor plants weekly from mid-June through August for initial signs of the borer's frass at entrance holes in the stems. Very early signs of larval feeding indicate that other eggs will be hatching soon. Use two insecticide applications 7 days apart to control newly hatching larvae and continue to monitor for additional activity. Sprays need to penetrate the canopy to cover the vines to be effective.

Squash Bug - The squash bug is another common pest. While all of the cucurbit crops can be attacked, it shows a preference for squashes and pumpkins. This insect can be very difficult to control when populations are allowed to build. Squash bugs damage plants by removing sap and causing leaves to wilt and collapse. Young plants and infested leaves on older plants may be killed.

Only the unmated adult bugs overwinter in Kentucky. Adult squash bugs begin to fly into fields and gardens about the time the plants begin to run. They remove plant sap with their piercing-sucking mouthparts. Soon after beginning to feed, they start laying eggs, primarily on the undersides in the angle between veins. The bronze eggs are football-shaped and lie on their sides in groups of 12 or more. Eggs hatch in one to two weeks. Initially the larvae are dark red with a light green abdomen. Older nymphs are light gray in color with black legs. Young nymphs are gregarious and feed in groups. Nymphs require five to six weeks to mature into adults. Squash bugs spend most of their time around the base and stems of the plants and on the undersides of leaves.



Management - Timing is the key to successful squash bug control. Insecticide sprays should target adults and small nymphs early in the season when the plants are small. It is much more difficult to control large numbers of older

nymphs and adults later in the season when the plant canopy is dense. Treat with a recommended insecticide if overwintering adults are causing seedlings to wilt.

Monitor for squash bug egg masses from prebloom through early flowering. Treat when egg mass numbers exceed an average of one per plant. However, eggs are not controlled by insecticides, so time insecticide applications to control young nymphs. Small nymphs are much easier to control with insecticides than larger nymphs or adults.

Cucumber Beetles - Striped and spotted cucumber beetles can cause serious losses in pumpkins in Kentucky. While the adults feed mainly on foliage, pollen and flowers, their feeding on the fruit surface late in the season that may reduce market quality. Cucumber beetles are a major concern to muskmelon and cucumber growers because they vector the bacteria that causes a disease, bacterial wilt of cucurbits, but this not as serious a problem in pumpkins.



Striped cucumber beetles are yellow-green with three black stripes down the back and 1/4 inch long. Although similar in appearance, the striped cucumber beetle and the western corn rootworm are not the same. The stripes on the striped cucumber beetle are straighter than those on the western corn rootworm. Additionally, the middle segment (tibia) of the hind leg on the striped cucumber beetle is yellow, while that on the western corn rootworm is black. The spotted cucumber beetle (also known as the southern corn rootworm), also 1/4 inch long, is yellow-green with 12 black spots on its back.



Cucumber beetles overwinter as adults in protected areas near buildings, in fence rows, or in wood lots. The beetles become active in mid-spring, as temperatures increase. Currently, there is no good method for predicting when the beetles will become active. Beetles quickly locate host plants in the spring. The adults feed and females deposit eggs in cracks in the soil at the base of

cucurbits. The eggs hatch and the larvae feed on the roots. These larvae will pupate in the soil and, later in the summer the next generation of beetles will emerge. These beetles will also feed on the cucumber and melon plants, including the

fruit. These are the beetles that will overwinter until the next spring.

Bacterial Wilt - The bacterium that causes bacterial wilt overwinters in the gut of some of the striped cucumber beetles. When beetles become active in the spring and begin feeding, they spread the bacterium either through their feces or from contaminated mouth parts. Beetle feeding on young leaves or cotyledons open entry points for the pathogen. Once inside the plant, the bacterium multiplies quickly in the vascular system, causing blockages that cause the leaves to wilt. Beetles are attracted to infected plants and can pick up the bacterium and move it to healthy plants. The first symptom of bacterial wilt on cucumber and muskmelon is a distinct flagging of lateral and individual leaves. While pumpkins are susceptible to this disease while small, once they pass through the first true leaf stage, their susceptibility to the disease declines.

One way to determine if bacterial wilt has infected a plant is to cut the stem and squeeze both cut ends. A sticky sap will ooze from the water conducting tissues of the stem. If you push the cut ends of the stem together and slowly pull them apart, you will be able to see a roping effect if bacteria are present. This sap contains millions of bacteria.

Management - Begin monitoring for cucumber beetles as soon as seedlings emerge. There is usually a peak in beetle activity each spring that lasts two to four weeks. This period of high activity is the most important time to control the beetles. Since pumpkins are not as susceptible to the wilt disease, protection is necessary only when plants are small and beetle populations are high. As the fruit begin to develop, monitor for cucumber beetles and treat as necessary to prevent feeding damage (scarring) to the fruits. Sevin and the pyrethroid insecticides provide effective control of cucumber beetles.

DISEASE CONTROL

Diseases can be very serious on pumpkins, especially when the plants have a heavy fruit set. Downy and powdery mildews, fruit rots, several viruses, and gummy stem blight are diseases that can cause serious losses. Growers should be prepared with the proper spray equipment and have the appropriate materials on hand (see table on p. 16).

Powdery Mildew - appears as a white powdery growth on leaves. Crown leaves that are infected first may wither and die. When powdery mildew symptoms are first observed, adjust your weekly spray schedule of Bravo to include Bayleton once every two weeks. Pumpkin varieties differ in their tolerance to powdery mildew and several breeding programs are working to develop more resistant varieties.

Gummy Stem Blight-Black Rot - is severe under very moist, humid conditions in Kentucky. Pumpkins develop primarily the black rot phase. Irregular circular fruit spots produce a dry rot. The fungus overwinters on the seed and plant residue. This disease occurs on the fruit, stems or leaves. Follow a 3-4 year rotation. Use fungicides on a 7 day schedule.

Choanenhora wet rot - results in a complete breakdown of the fruit tissue. Warm moist weather favors this disease. The disease is often serious at bloom and attacks the young fruit.

Downy Mildew - produces irregular yellowish shaped or brown spots on the upper leaf surface usually in the center of plants and mold develops on these spots. Downy Mildew spreads from the crown towards the new growth. It usually appears late in summer during foggy or humid periods and can kill plants rapidly like Blue Mold on tobacco. Use Ridomil/Bravo if conditions favor this disease.

Virus Complex - vines on virus-infected plants are stunted and new leaves are dwarfed, mottled and distorted. Perennial weeds serve as a source of viruses. Eliminate broadleaf weeds within 150 feet of the planting and use corn as a barrier crop between the crop and weedy areas. Do not plant near tobacco fields as tobacco crops are often a major source of aphids which vector virus diseases. Viruses can be a severe problem in some locations. Most viruses are carried by aphids to the pumpkins, but cucumber mosaic virus may also be carried by cucumber beetles.

Fusarium Fruit Decay - Initially in 1995 and at higher levels in 1996 samples of rotting pumpkin fruits were observed. In several fields and markets this decay caused serious preharvest and post-harvest losses. In 1996 the incidence of rot was well above the levels experienced in Kentucky in recent years. The most common pathogen involved that year was Fusarium fungi, but other microbes have also been involved, but to a much lower level.

The reasons for the higher disease levels are not fully understood, but here are some factors that are probably contributing. Cooler and wetter weather prevailed in 1996, favoring high disease activity for both foliage and fruit. The virus complex, powdery mildew, and downy mildew all had been very active and caused stunting of plants and loss of foliage. Fruits produced under strong foliar disease pressure are usually of low quality and more susceptible to rotting.

At several of the field sites visited, it was obvious that foliar disease control had not been achieved and early defoliation had occurred. Both at market stands and in the field, there also appeared to be a positive correlation between virus-infected vines or fruits, and fruit rots.

While gummy stem blight (black rot) and anthracnose were

present in 1996, a high percentage of the rots appeared to have been caused by Fusarium, and this is new for us. Particularly surprising, was the high incidence of immature fruits covered with lesions containing Fusarium. We have seen a wide range of symptoms associated with Fusarium - ranging from dry, pitted canker-type lesions, sunken areas, spongy-rotted areas, stem-end rots, blossom-end rots, with a range of fungal signs from white, brown, purple or red fungal growth. Most common was a small lesion with a dry center and dark halo. This lesion-type was also present on mature fruit, both in the field and at the market stands, but many of these lesions began to expand into a soft rot (larger sunken and wet lesions) as the fruits aged.

Several Fusarium species are known to be involved in rotting of pumpkin fruits. Although some research is underway, how the disease develops is not well understood. The following general principles seem to apply at this point. Fusaria are able to attack through wounds and even directly through the tissue under wet conditions, especially before the fruit develop a mature rind. Inoculum is probably abundant, because some of these Fusaria are **internally or externally seed borne** and a large number of other hosts maybe involved. Planting fungicide treated seed might help reduce the chance of disease from infested seed. Some of the Fusaria involved may respond to rotations (four year rotations are usually recommended) away from cucurbits, while other Fusaria probably will not. Many of the worst fields had been in pumpkins for more than a year. *Growing pumpkins without rotation may be playing a significant role in the disease.* There may be pumpkin cultivar differences in susceptibility, but that has not been well established yet.

The bottom line is too little is known about the Fusarium diseases of pumpkins to formulate specific controls at this time. More research is needed to develop a good understanding of these diseases. Until this happens, all we can recommend are some general principles: **(1) Maintain effective fungicide programs for foliar diseases. (2) Use fungicide treated seed. (3) Do not plant pumpkins following pumpkins or other cucurbits. (4) Store only pumpkin that are mature and apparently free of lesions, and especially avoid long-term storage of those from fields with serious outbreaks of fruit rots.**

Growers should follow a good crop rotation schedule to reduce the build up of insect and disease populations, scout the fields on a regular basis and use chemical sprays where necessary, and refer to ID-36, Commercial Vegetable Crop Recommendations available from your Extension office.

INFLUENCE OF WEATHER ON PUMPKIN FLOWER AND FRUIT PRODUCTION

Pumpkin plants produce separate male and female flowers, which usually open about 40 days after sowing. The first ten nodes or so on the plant will produce all male flowers before the female flowers begin appearing. Since the females turn into pumpkins if pollinated, it is important to know under what conditions they may be delayed in development. Some varieties of pumpkins grown under high temperatures (90 degree days and 70 degree nights) produce female flowers that wither and die before they open. In 1995, we saw many withered female flowers in an irrigated pumpkin field at Quicksand. Similarly, if pumpkin plants are heavily shaded, the same thing may happen. Under both situations, male flowers develop normally and open on schedule but few if any female flowers are seen. The variety "Howden's Field" is particularly susceptible to this problem.

Pumpkin plants, like other cucurbits, subjected to drought stress when the plants are at the 2-to 3-leaf growth stage (in June and early July in Kentucky) tend to develop a high male to female flower ratio. Pumpkin flower differentiation begins at this 2-to 3-leaf plant stage. A delay in fruit set will occur if conditions are bad enough. For pumpkins, this is not necessarily bad because the pumpkin plants may have an enhanced capacity to support more large fruit due to a larger vine size. Of course, this only happens if weather conditions return to more optimum conditions for pumpkin fruit development. Growers of prize winning large pumpkins are essentially doing the same thing when they remove the first 2-3 female flowers before letting one set and develop a fruit. They then remove any latter developing fruit so that all the plant's energy goes into one large fruit. Unfortunately, heat and dry weather are sometimes the norm for KY into mid-September, resulting in reduced fruit set and size.

A split fruit set may also occur if pumpkin plants are subjected to drought stress shortly after they start setting fruit. This causes the development of a few crown fruit at the first few female flower nodes, resulting in a crop of poor quality (small vine and fruit size, early maturity). When pumpkin fruit are subjected to high temperatures during development they tend to mature early and may not keep until the traditional market season.

The implications of these findings are that hot weather conditions may delay fruit production because no female flowers open during that period. The shade effect which also delays female flowers could occur when pumpkins are planted at dense spacing, and/or are given large amounts of nitrogen fertilizer. This might allow so much plant growth, that the individual plants would be shading each other, consequently shading the developing female flowers, resulting in delayed flower development. A similar situation could occur if weed control is poor, and the weeds become tall enough to shade the pumpkin plants.

A New York state pumpkin spacing experiment on a silt loam soil in 1995 showed, the variety Howden tended to have reduced fruit yield at high plant density (plants spaced 1.5 x 6 feet, with two plants per hill). Wizard, on the other hand showed no yield decrease at that spacing, so there may be varietal differences in this effect.

Hot, dry growing seasons make pumpkin production a real chore, and under these conditions few growers are able to get high yields. As mentioned many factors can contribute to low productivity, but the common grower complaint is that they see few pumpkins in their fields at harvest. Usually we blame poor fruit set on hot, dry conditions. Sometimes this may indeed be the case, however the problem may have actually occurred at an earlier growth stage. To understand what might be happening, we need to understand the normal process of pumpkin flower development and fruit set, and to realize how the environment and other factors may influence these events.

High temperatures also seem to have an effect on the seed set. Pollen viability is affected and its' germination rate decreases. This results in poor germination (seed development) and constricted fruit development. The fruit becomes pointed and narrow at the stem end. Placental hollows may also be a problem, if the seed set is poor.

Because of poor pumpkin fruit set, vigorous vine growth could result should rains occur later in combination with warm, sunny weather. This is especially true if the nitrogen content in the soil is relatively high. Indications of such a problem would be light colored fruit from too much foliage shading. Rapid pumpkin fruit development results in less chlorophyll in the fruit contributing to their lighter color. This problem tends to occur in heavier soils where nitrogen is abundant or when growers attempt to overcome drought stress by applying additional fertilizer.

High temperatures and humidity in combination with rank vine growth are also an ideal site for disease development. Good spray coverage is very difficult when rank vine growth occurs. Virus problems were (are) one of the major problems seen in any year's pumpkin crop. Hot dry weather conditions favor early aphid migration into young developing plants. Based on symptoms, Cucumber mosaic virus and watermelon mosaic virus II appear to be the major viruses involved. At Quicksand pumpkin plants infected with cucumber mosaic develop wilt and death of crown leaves leaving some fruit exposed to the sun in late August.

POLLINATION AND FRUIT SET

Plan ahead for bee pollination of vine crops. Availability of strong hives may be limited. Bees are essential for commercial production of all vine crops. Because pumpkins have separate male and female flowers on the same plant, bees must carry pollen from the male flowers to the female flowers in order to have fruit set. If several acres are involved it will usually require bringing in bees for pollination purposes. Over the past several years parasitic mite infestations in most areas of the state have severely weakened and depleted wild honey bee populations.

Cucumbers, squash, pumpkins and watermelons have separate male and female flowers, while muskmelons have both male and hermaphroditic (perfect or bisexual) flowers. The sticky pollen of the male flowers must be transferred to the female flowers to achieve fruit set. Lack of adequate pollination usually results in small or misshapen fruit in addition to low yields. The size and shape of the mature fruit is usually related to the number of seed produced by pollination, each seed requires one or more pollen grains.

Cucurbit flowers remain open and attractive to bees for only a day or less. Pumpkin, squash and watermelon flowers normally open around daybreak and close by noon; whereas, cucumbers and muskmelons generally remain open the entire day. Pollination must take place on the day the flowers open, since pollen viability, stigmatic receptivity, and attractiveness to bees last only that day. Bees need to be present when the female flowers begin appearing. For pollination to occur, pollen must be transferred from male to female pumpkin flowers. This is accomplished by bees, most commonly honey bees, but bumblebees and other native bees can also be involved. It is important to know that pumpkin flowers are only open in the morning, and will close by noon, or earlier if the weather is warm. Pollination has to be completed in less than six hours, and if very warm conditions or windy, rainy weather prevails, the flowers open that day may not be pollinated and will therefore not develop into fruit. If an adequate population of bees is present in the field, and the plants have produced female flowers, the fruit that make it to maturity will have been set within a three-week period, starting from the time the first female flowers open. You can tell if there is an adequate number of bees visiting the field, and doing the pollinating, in a couple of ways. One is tedious, and not practical for busy growers. That is, to actually stand in the field on a morning on which the female flowers are open, and observe the bees visiting the flowers. **At least one bee should visit a female flower every 15 minutes to get adequate pollination.** Growers should be very careful not to spray an insecticide during the daytime when bees are active.

The second method is indirect. By looking at the male flowers after they have closed (in the afternoon), you can

observe how much pollen is left on the anther. If little or no pollen has been removed, you can assume that there has been little bee activity, and you might have a fruit set problem. Anthers that have had little or no pollen removed will appear fluffy and you can remove the pollen with your fingers. Anthers that have had most of their pollen removed will look like corduroy with white and yellow stripes. Little or no pollen will be removed with your fingers.

Even though bumblebees and other species of wild bees are excellent pollinators, populations of these native pollinators usually are not adequate for large acreages grown for commercial production. The best way to ensure adequate pollination is to own colonies or rent strong colonies of honeybees from a reliable beekeeper. Commercial bee attractants, such as Bee Scent or Bee Here, have not proven to be effective in enhancing pollination.

Bee activity is determined, to a great extent, by weather and conditions within the hive. Bees rarely fly when the temperature is below 55°F (12.8°C). Flight seldom intensifies until the temperature is 70°F (21.1°C). Wind speed beyond 12 mph seriously slows bee activity. Cool, cloudy weather and threatening storms greatly reduce bee flights. In poor weather, bees foraging at more distant locations will remain in their hive, and only those that have been foraging nearby will be active.

Ideally, colonies should be protected from wind and be exposed to the sun from early morning until early afternoon. Colony entrances facing east or southeast encourage bee flight. The hives should be off the ground and the front entrances kept free of grass and weeds. A clean water supply should be available within a quarter mile of the hive.

The number of colonies needed for adequate pollination varies with location, attractiveness of crop, density of flowers, length of blooming period, colony strength, and competitive plants in the area. **In vine crops, one to two colonies per acre are recommended, with the higher number on high density plantings.** Each hive or colony should contain at least 1,200 square inches of brood and enough adult bees to care for the brood, regardless of weather conditions.

Finally, even with adequate fruit set, the pumpkin fruit yield can still be low. In the 1995 season, lack of irrigation caused a marked decrease in fruit size and handle strength and instead of orange, a yellow skin color developed. Some years, the use of irrigation will pay a big dividend in terms of quality and yields. In years like 1995 a good irrigation system which could have applied 1-2 inches of water a week and kept ground temperatures a little cooler would have helped yields and paid for itself.

HARVESTING

Pumpkins are normally harvested when they reach a deep solid color and the rind is hard. Pumpkins that are picked when they are green and immature will not color up. **In emergencies--late maturity, fruit rots occurring, or large insect populations present--it is possible to harvest pumpkins at the mature green stage and most of them will color up within a few weeks. At the mature green stage the skin has toughened up and can't be punctured with your fingernail. It is recommended, however, that pumpkins undergo at least some change in color before harvesting.**

Cut pumpkins from vines carefully leaving a 3 to 4 inch stem attached. Pumpkins do not all mature at the same time on the plant, but will continue to color up over a period of three to four weeks, if diseases and insects are held in check. Cloudless (sunny) weather is especially important in the development of mature fruit with good color.

When harvesting, use a pair of loppers, pruning shears or a sharp knife to snip the large stem from the plant which makes for a more attractive stem and also prevents the stem from separating from the fruit. Pumpkins are best harvested when the rind is hard and has good color characteristics typical of the variety. Do not handle or carry the pumpkin by its stem or "handle" since these often break off reducing the marketability of the pumpkin and reducing storage life by encouraging decay.

STORAGE AND POSTHARVEST CARE

It may be necessary to harvest and hold pumpkins in storage for two to four weeks before they are marketed. Tobacco barns are usually a good place for storage. Spread out a layer of dry straw or hay and set the pumpkins on this. Keep the pumpkins dry. Do not store pumpkins on bare ground after harvest. Good air circulation will help reduce rotting. Pumpkins should be harvested and stored before temperatures drop to the 30's and 40's.

Although pumpkin harvest for Halloween usually begins in mid September - early October, in some seasons, due to warm weather early maturity may occur. Unfortunately, pumpkins that mature in late August and early September often rot or decay long before market time in early - to mid October. Some rot is unavoidable, caused by injury or seasonal stresses such as drought and/or heat. Diseases such as powdery or downy mildew, viruses or gummy stem blight may also cause premature ripening. There are a few precautions which should be taken to minimize the decay of prematurely ripened fruit. Harvest should begin earlier! Get the pumpkins out of the field when they mature early. Pumpkins should be handled carefully to avoid cuts and bruises, which are the major entry points for rotting fungi

and bacteria. **A curing period of 7-10 days at temperatures of 80 to 85°F with relative humidities of 80 to 85% has been recommended in the past to heal over surface injuries and allow for further ripening; however, this is seldom practiced and research in New York has shown that it may not be necessary. It was not beneficial for several types of squash including Butternut types and was detrimental to Acorn squash.**

Store pumpkins cool and dry; storage temperatures should be 50-55°F with a relative humidity of 50-70%. The surface of the fruit should be dry. Keep the area as well ventilated as possible and away from any ethylene sources (tomatoes, apples). Ventilation can be provided by placing fruits on pallets or slatted benches which allow air movement around the fruits. Avoid stacking pumpkins on top of one another. Stacking is a sure way to create bruises and the pile will only create unwanted heat. **It is possible to hold pumpkins for 6-8 weeks when held at 50-55 degrees but only for a few weeks at 70 degrees.**

What can you do when pumpkins are still green in October and not yet ready for market? Prevention is the key--plant early enough for the variety you have selected and be careful not to over fertilize with nitrogen which can delay maturity. Green *mature* pumpkins can be harvested (**see Harvesting section**) but are not as likely to color up uniformly. Avoid temperatures below 50 degrees which can cause chilling injury to green mature pumpkins and will result in poor color and more fruit decay. One possibility is to put green or partially colored pumpkins in a warm greenhouse which will accelerate the maturing process. Proper postharvest care is always a good investment of time and energy especially since supplies may be short after growing seasons which result in orange pumpkins in August or green pumpkins in September.

YIELDS, MARKETING, AND RETURNS

A grower might expect around 700 to 800 pumpkins per acre of the extremely large, exotic type pumpkins. One grower has reported that he gets \$20.00 to \$25.00 per pumpkin for these large ones, but the demand is limited. For the 15-24 pound size Halloween pumpkins, a yield of 2,000 to 2,500 per acre is reasonable if irrigation is available and diseases are controlled. For the smaller 8 to 10 pound size, up to 4,000 per acre can be expected. For the miniature or ornamental pumpkins that weigh less than one half pound each, a grower might expect 40,000 to 70,000 per acre.

Gross returns may vary from \$2000 to \$6000 per acre depending on cultural techniques and the marketing method. Prices received and therefore returns per acre can vary greatly depending on supplies available and the marketing channel used. Higher and more stable prices can be expected from direct sales or even "pumpkin festival" sales, but this

market can become saturated with too many growers around a population center. In some cases smaller growers can help supply the larger festival market grower for prices that may be higher than wholesale. Larger producers and those who don't have time for direct sales will need to find wholesale buyers or in some cases can sell directly to supermarkets. Wholesale prices are often considerably lower than direct market (retail) prices. Smaller growers should consider joint marketing efforts in order to attract wholesale buyers. Good production, management and marketing can result in high profits when supplies are short; with more growers getting into pumpkin production, some markets may disappear leaving production unsold.

Total out-of-pocket costs for seed, fertilizer, herbicides, insecticides, fungicides, land preparation, and irrigation will usually be about \$600 per acre. Harvesting, handling and storage may require around 70 hours of labor or \$489.00 for harvesting and handling.

SCHEDULE FOR DISEASE AND INSECT CONTROL IN PUMPKINS AND WINTER SQUASH

Regular fungicide and insecticide sprays are needed to successfully produce pumpkins in Kentucky. The information provided here is also available in ID-36.

The most common insect problems are cucumber beetles, squash bugs and squash vine borer. If bacterial wilt susceptible cultivars are grown cucumber beetle control should begin as soon as plants emerge (similar to cucumber or cantaloupe), otherwise control only when moderate populations are present. Control of squash bugs and vine borers should start when pumpkin vines begin to run and continue on a regular basis.

The most common and damaging diseases of pumpkins and winter squash encountered in Kentucky in recent years have been seedling damping-off, gummy stem blight (or black rot of the fruit), powdery mildews, downy mildew, fusarium, anthracnose, bacterial wilt and viruses. So far, *Phytophthora* blight has not been an identified problem here, but is very common in states to our north. Growers should take the following steps to minimize these and other important diseases of pumpkins in Kentucky.

Steps:

1. Crop rotation is important in pumpkin disease control because several diseases survive from season to season in the soil and crop debris. Select a field that has not been grown to members of the cucurbit (cantaloupes, cucumbers) or nightshade families (peppers for example) for a least two years, wait 3 to 4 years if the field has a history of gummy stem blight of cucurbits.

2. Locate fields as far away from existing earlier cucurbit plantings as possible to minimize spread of the virus complex by aphids.

3. Use Thiram treated seed (1/2 teaspoon per pound of seed).

4. Insect control is essential on some cultivars in order to control bacterial wilt spread by the **striped and spotted cucumber beetles**. In plantings susceptible to bacterial wilt, cucumber beetles need to be controlled before they feed on seedlings. Control should begin at plant emergence and continue until flowering by using a recommended insecticide. In plantings resistant to bacterial wilt, an insecticide is recommended only when moderate to large numbers of cucumber beetles are present.

Squash vine borers can also be serious in some plantings. Squash vine borers must be controlled on a preventive basis, once inside the stems there is no effective control. A weekly application of an insecticide starting when the vines begin to run is recommended. After harvest is complete, deep tillage or removal of crop residue will help to delay and/or reduce infestation the next spring.

Squash bugs may begin to appear in squash and pumpkin fields about the time vines begin to run. Fields should be monitored for the insects regularly. When eggs (underneath leaves) or small nymphs are observed, plants should be sprayed with an insecticide. Timing is important, larger nymphs are much more difficult to control with insecticides than small nymphs. After harvest is complete, deep tillage or removal of crop residue will help to delay and/or reduce infestation the next spring.

5. For broad-spectrum control of leaf, stem and fruit diseases caused by fungi, use a weekly fungicide application, starting no later than when vines begin to run, or earlier if disease develops. [Note: No consideration was given to cost in the schedule below, only to what will give high levels of disease control under serious disease pressure.

In a weekly spray schedule, use Bravo 720 at 2 to 3 pts/acre or Bravo 90DF at 1.5 to 2.5 lbs/acre. It is important to continue to spray on a 7 day schedule in rainy weather, but the interval can be extended to 10 days when there is no rain or even to 14 days under drier conditions (no fog or dews). This schedule will provide a high level of control for anthracnose and gummy stem blight (black rot) and will significantly suppress powdery and downy mildews, but more effective materials than Bravo will be needed under strong pressure from the mildews.

Powdery mildew is a problem to some degree every year in nearly every pumpkin planting in Kentucky, often present from mid-July to frost. With the first signs of powdery mildew (white powdery growth on the leaves) add Bayleton

at 2 to 4 oz/A on a 14 day interval. Bayleton is highly effective against the most common species of powdery mildew encountered in KY, but sometimes Bayleton fails when certain strains of powdery mildew are present. Therefore, watch closely for powdery mildew and adjust the schedule if necessary. Benlate 50 W at 0.5 lbs/A or Topsin M 85 WDG at 0.25 to 0.5 lbs/A can be used in the offweek in the Bayleton schedule if adequate control of powdery mildew is not being achieved with the Bravo and Bayleton program. If Bayleton is not working for you, please promptly contact the county extension office so that others can be advised.

Downy mildew is much more erratic in occurrence in Kentucky than is powdery mildew, but when present it can be very destructive within a few days. This fungus is closely related to the tobacco blue mold disease and has similar requirements for its development, so if tobacco blue mold (tobacco downy mildew) is present or a blue mold advisory exists for the area, assume that it also applies to pumpkin downy mildew. The first symptoms of downy mildew are yellow spots on otherwise healthy leaves and the signs are a white to gray downy fungus growth on the underside of the lesions (observable in the early morning while the leaf is wet). To control downy mildew, substitute Ridomil/Bravo 81 WP at 2 to 3 lbs/A for the Bravo alone on a 14 day schedule. Be sure to maintain the Bravo in the alternate week, however, to maintain black rot control. Some states report using fixed coppers successfully instead of Ridomil/Bravo, but we have had limited experience with that option in Kentucky.

6. If other insects or diseases become a problem, get them diagnosed promptly and properly so changes in the control programs can be made if necessary. Also, be sure to harvest fruits promptly upon maturity and before frost. If fruit are to be stored, avoid chill damage which occurs at temperatures below 50°F, because it greatly predisposes fruit to a number of storage diseases and disorders and greatly reduces shelf-life.

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