# Variety Trials

## Adaptation and Market Potential of Jack o' lantern and Miniature Pumpkin Cultivars in Eastern North Carolina

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**Additional index words.** *Cucurbita pepo*, papaya ringspot virus, Phytophthora nicotianae, postharvest fruit decay, southern blight, vegetable production, watermelon mosaic virus, zucchini yellow mosaic virus, yield

**Summary.** In 1998 and 1999, a total of 27 large-fruited and 15 miniature-fruited pumpkin (*Cucurbita pepo*) cultivars were evaluated for adaptation to eastern North Carolina growing conditions. Test categories were yield (fruit number and weight); fruit characteristics (shape, rind and stem attributes); and susceptibility to edema (wart-like growths on fruit exterior), foliar diseases, preharvest and postharvest fruit decay, and viruses. Yields of large pumpkins ranged from over 3,200 fruit/acre (7,907 fruit/ha) for 'SVT 4613367', 'Autumn Gold', and 'Gold Standard' to less than 1,000 fruit/acre (2,471 fruit/ha) for 'Gold Rush' and 'Progold 200'. For miniature pumpkins, over 33,000 fruit/acre (81,542 fruit/ha) were produced by 'Touch of Autumn', 'Lil' Pumpke-mon', and 'HMX 5682', whereas 'Mystic' and 'Progold 100' produced less than 7,000 fruit/acre (17,297 fruit/ha). 'Gold Rush', 'Howden', and 'Progold 510' (large), and 'EXT 4612297', 'Lil' Goblin', and 'Lil' Ironsides' (miniature) appeared the most susceptible to foliar diseases. Preharvest fruit decay ranged from 0% for 'Howden' and 'EXT 4612297' to over 20% for 'Lil' Goblin', 'Jumping Jack', 'Peek-A-Boo', and 'Tom Fox'. Virus incidence on fruit and foliage was low on virus-resistant cultivars ('SVT 4613367' and 'EXT 4612297'), and ranged from 4% to 74% for nontransgenic cultivars. Virus incidence and/or severity on foliage and fruit were not related. 'Early Autumn' (large) and 'Touch of Autumn' (miniature) were the most prone to edema. 'Aspen' and 'Magic Lantern' (large) and 'Baby Pam', 'Lil' Goblin', and 'Spooktacular' (miniature) were the most susceptible to postharvest fruit decay. Fruit characteristics are discussed in relation to marketability and possible consumer appeal to pumpkins.

Selecting regionally adapted pumpkin cultivars is critical for producing high yielding, quality pumpkins. In the United States, most commercial pumpkin production occurs in the central and northern states (Peirce, 1987). However, the high demand for pumpkins for autumn holidays like Halloween and Thanksgiving has prompted an interest in pumpkin production for growers in the southeastern states, a region where temperatures, disease and insect pressures are considerably different from those found in other areas of the county (Elmstrom et al., 1988). These southeastern U.S. conditions have hampered growers' ability to produce pumpkins successfully and profitability. For example, Wien et al. (1998, 2002) demonstrated that the high temperatures typical of the southeastern U.S. (Florida) delayed and reduced 'Howden' pumpkin yields, whereas quality yields were obtained in cooler northern states such as Maryland and New York. While pumpkin flowering and fruit set problems also may occur in northern growing regions, Stapleton et al. (2000) suggested that climatic conditions may be secondary to physiological factors. In South Carolina, Keinath and DuBose (2000) concluded that none of the pumpkin cultivars they evaluated were well-adapted to the humid growing conditions of the southeastern U.S. coastal plain. Downy mildew (*Pseudoperonospora cubensis*), powdery mildew (*Sphaerotheca fuliginea*), papaya ringspot virus (PRSV), watermelon mosaic virus (WMV), and zucchini yellow mosaic virus (ZYMV) are also known to reduce yields of sensitive squash and pumpkin cultivars (Bost et al., 1991; Keinath and DeBose, 2000; Schultheis and Walters, 1998; Shoemaker, 1994).

In North Carolina, it is often challenging to grow a profitable crop in the eastern part of the state. High temperatures often seem to inhibit fruit set, and disease often reduces the production and quality of the pumpkin crop. In extreme cases, entire pumpkin crops have been lost to flooding or disease, especially when hurricanes or tropical storms have deposited large amounts of moisture. Growers are reluctant to intensively manage a pumpkin crop; thus, irrigation is often lacking and pest management minimal or not optimized.

To overcome these production shortcomings, growers are interested in pumpkin cultivars that have increased pest resistance and better fruit set under the growing conditions of eastern North Carolina. 'Howden' has been a standard pumpkin cultivar for North Carolina growers for years, but yields are often disappointing. Many pumpkin cultivars are constantly being developed or released. Several newly released cultivars have improved disease resistance (powdery mildew-resistant cultivars

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and transgenic, virus-resistant lines), which also may be more tolerant than 'Howden' to the high temperatures in the southeastern U.S.

The objectives of our 2-year study were to compare the regional adaptability of jack o' lantern (large- to medium-sized fruit) and novelty (small- to miniature-sized fruit) pumpkins to the growing conditions in eastern North Carolina. Several production factors were evaluated, including overall yield potential; susceptibility to downy and powdery mildews, viruses, and preharvest and postharvest fruit decay; and fruit characteristics such as fruit shape, rind and stem attributes. The susceptibility of pumpkin cultivars to edema (small, rough, achromatic, wart-like protrusions on the fruit exterior) was also assessed, as fruit with severe edema may be classified as culls due to the unattractiveness this condition imparts. The cause of edema in pumpkin is uncertain, but it is believed to be a physiological condition (Blancard et al., 1994). Based on these qualities, we wanted to use this information to develop recommendations for growing pumpkin cultivars in North Carolina and surrounding southeastern states. We also wanted to provide supplemental irrigation and prophylactic pest management practices to illustrate and maximize pumpkin fruit quality and yield potential.

## Materials and methods

Pumpkin cultivars were evaluated in 1998 and 1999 at the Central Crops Research Station in Clayton, N.C. Clayton is located at the border of the Piedmont and Coastal Plain regions in North Carolina, where average temperatures are several degrees cooler than those in points east in the Coastal Plain. The most promising cultivars from several seed companies were tested each year, including powdery mildew-resistant cultivars ('Aladdin', 'Magic Lantern', 'Merlin', 'Mystic Plus', and 'Touch of Autumn'), and several transgenic, virus-resistant lines ('SVT' and 'EXT' cultivars resistant to WMV and ZYMV). The large- to medium-fruited cultivars (hereafter called large pumpkins) we evaluated are listed in Table 1, and small- to miniature-fruited cultivars (hereafter called miniature pumpkins) are listed in Table 2. In addition to new cultivars, we included large ('Autumn Gold', 'Frosty', and 'Howden') and miniature ('Baby Pam' and 'Spooktacular') pumpkin cultivars that are commonly grown in North Carolina (Schultheis, 1998). Soil type in 1998 was 90% Appling Sandy Loam (fine, kaolinitic, thermic Typic Kanhapludult) with 10% of the field Gilead Loamy Sand (fine, kaolinitic, thermic Aquic Hapludults). Soil types in 1999 were Bibb Soil (coarse-loamy, siliceous, active, acid, thermic Typic Fluvaquents) (75%) and Goldsboro Loamy

**Table 1. Seed source, mean fruit weight, yield, number of fruit/acre, degree of suturing, stem and rind color, stem length and diameter, and fruit shape for 27 large pumpkin cultivars grown in eastern North Carolina.[z]**

| Cultivar | Seed source[y] | Year[x] | Individual fruit wt (lb ± SD) | Fruit yield (lb/acre)[w] | Fruit/ acre (no.) | Suture[v] | Stem color[u] | Stem length (inches)[t] | Stem diam (inches)[s] | Rind color[r] | Fruit shape description[q] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SVT 4613367 | SV | 99 | 9.1 ± 2.9 | 26,950 | 3,412 | 1.6 | 3.3 | 7.3 | 2.2 | 2.2 | Tall |
| Autumn Gold | NV | 98, 99 | 6.7 ± 2.1 | 23,140 | 3,365 | 2.4 | 3.3 | 6.4 | 2.6 | 2.0 | Round |
| Gold Standard | RP | 99 | 9.9 ± 2.9 | 32,010 | 3,231 | 2.6 | 3.3 | 9.4 | 3.8 | 2.7 | Tall |
| Gold Fever | RP | 98, 99 | 8.9 ± 3.6 | 28,360 | 3,110 | 1.5 | 3.2 | 8.6 | 3.3 | 2.0 | Round |
| Merlin | HM | 98, 99 | 12.7 ± 3.9 | 37,010 | 2,868 | 3.4 | 3.4 | 9.0 | 2.8 | 2.8 | Round |
| Magic Lantern | HM | 98, 99 | 12.7 ± 3.7 | 36,680 | 2,867 | 2.4 | 3.5 | 7.9 | 2.6 | 2.6 | Round |
| Frosty | HL | 98, 99 | 9.3 ± 3.9 | 23,080 | 2,580 | 1.8 | 3.1 | 5.6 | 2.2 | 1.8 | Round |
| Howdy Doody | RP | 98, 99 | 11.1 ± 3.7 | 26,840 | 2,406 | 2.6 | 3.2 | 5.0 | 3.3 | 2.4 | Round |
| REX 38040 | RP | 98, 99 | 11.4 ± 3.8 | 24,990 | 2,222 | 2.0 | 3.0 | 7.2 | 4.1 | 2.1 | Round |
| Racer | JS | 98, 99 | 8.3 ± 3.1 | 18,180 | 2,177 | 2.6 | 3.3 | 8.0 | 3.1 | 2.4 | Round |
| Early Autumn | NV | 98, 99 | 11.4 ± 3.5 | 24,540 | 2,164 | 2.6 | 3.5 | 6.7 | 2.4 | 2.3 | Round |
| SVT 4622837 | SV | 98 | 14.8 ± 3.7 | 25,720 | 1,815 | 1.5 | 3.0 | 6.6 | 2.6 | 1.9 | Tall |
| Jack of all Trades | HL | 98, 99 | 9.7 ± 3.4 | 19,640 | 1,972 | 1.6 | 2.4 | 8.8 | 3.1 | 1.8 | Round |
| Appalachian | PS | 99 | 13.3 ± 3.2 | 26,250 | 1,959 | 2.8 | 3.4 | 5.8 | 2.1 | 2.5 | Round |
| Progold 510 | AC | 98, 99 | 14.0 ± 4.4 | 26,030 | 1,850 | 3.4 | 3.5 | 7.2 | 2.4 | 2.4 | Round |
| EX 4622827 | SV | 99 | 13.4 ± 3.3 | 24,130 | 1,850 | 3.7 | 2.6 | 6.2 | 2.0 | 2.2 | Round |
| Mother Lode | RP | 98, 99 | 14.3 ± 5.8 | 26,040 | 1,790 | 2.3 | 3.4 | 6.1 | 2.3 | 2.0 | Tall |
| Happy Jack | PS | 98, 99 | 9.4 ± 2.8 | 16,590 | 1,755 | 2.0 | 2.9 | 7.2 | 2.0 | 2.4 | Round |
| Aspen | HL | 98, 99 | 13.6 ± 4.5 | 23,270 | 1,699 | 2.8 | 3.4 | 5.2 | 2.8 | 2.2 | Round |
| Aladdin | HM | 98, 99 | 14.2 ± 6.0 | 24,740 | 1,696 | 2.8 | 3.5 | 6.2 | 3.1 | 2.4 | Round |
| Jumping Jack | HL | 98, 99 | 15.8 ± 5.2 | 22,800 | 1,485 | 2.0 | 3.2 | 7.8 | 2.6 | 2.1 | Tall |
| Tom Fox | JS | 98, 99 | 9.1 ± 3.2 | 11,880 | 1,362 | 1.9 | 2.4 | 8.0 | 2.6 | 2.3 | Round |
| Autumn King | SD | 99 | 19.4 ± 5.4 | 26,000 | 1,310 | 1.7 | 3.2 | 9.2 | 2.3 | 1.6 | Tall |
| Howden | HM | 98, 99 | 14.3 ± 5.1 | 17,720 | 1,260 | 2.7 | 3.2 | 7.4 | 3.1 | 2.4 | Round |
| Gold Strike | RP | 98, 99 | 15.3 ± 6.2 | 18,230 | 1,162 | 2.6 | 3.3 | 6.6 | 2.7 | 2.2 | Round |
| Progold 200 | AC | 99 | 12.8 ± 3.5 | 12,370 | 943 | 2.8 | 3.3 | 8.0 | 2.5 | 1.9 | Round |
| Gold Rush | RP | 98, 99 | 18.4 ± 6.9 | 10,590 | 545 | 3.3 | 3.2 | 7.7 | 3.4 | 2.3 | Round |
| LSD ($P < 0.05$)[z] | | | 2.7 | 10,860 | 770 | 0.5 | 0.5 | 1.8 | 0.6 | 0.4 | |

[z]Values are the means of eight (1998 and 1999) or four (1998 or 1999) replications. Least significant difference (LSD) values are applicable to cultivars tested in both years only. Cultivars are ranked by number of fruit/acre.
[y]Seed source: AC = Abbott and Cobb (Feasterville, Pa.), HL = Hollar and Co. (Rocky Ford, Colo.), HM = Harris Moran (Modesto, Calif.), JS = Johnny's Selected Seeds (Winslow, Maine), NV = Novartis (Boise, Idaho), PS = PetoSeed (Saticoy, Calif.), RP = Rupp Seed (Wauseon, Ohio), SD = Seeds by Design (Willows, Calif.), and SV = Seminis Vegetable Seed (Oxnard, Calif.).
[x]98 = 1998, 99 = 1999.
[w]1 lb/acre = 1.12 kg·ha$^{-1}$.
[v]Suture (degree of exterior fruit ribbing) rating: 0 (no sutures); 1 (minimal sutures); 2 (light sutures); 3 (moderate sutures); 4 (heavy sutures).
[u]Stem color rating: 1 (no green); 2 (yellowish-green); 3 (medium green); 4 (dark green); 5 (solid, dark green).
[t]1 inch = 2.54 cm.
[s]Stem diameter measured 1 inch above stem base using calipers.
[r]Rind color (intensity of orange) rating: 1 = light orange, 2 = medium orange, and 3 = dark orange.
[q]General fruit shape: round (spherical) or tall (horizontally compressed).

Sand (fine-loamy, siliceous, subactive, thermic Aquic Paleudults) (25%).

Twenty-seven large (21 in 1998; 26 in 1999) and 15 miniature (11 in 1998, 15 in 1999) pumpkin cultivars were included in each respective test. For large pumpkins, plots were 40 ft (12.2 m) long with a 10-ft (3.0-m) alley between plots. Center-to-center row spacing was 8 ft (2.4 m) and in-row spacing was 4 ft (1.2 m) (10 plants/plot). For the miniature pumpkins, plots were 20 ft (6.1 m) long with a 10-ft alley between plots. Center-to-center row spacing was 8 ft and in-row spacing was 2 ft (0.6 m) (8 plants/plot). Three to five seeds were direct seeded on 15 June 1998 and 21 June 1999 and thinned to one plant per hill after seedling emergence.

The following cultural and pest management practices were used (North Carolina State University, 1997; Schultheis, 1998). Preplant fertilizer (12N–6P–24K) was disc-incorporated at 400 lb/acre (448.3 kg·ha$^{-1}$) several days before seeding, and 200 lb/acre (224.2 kg·ha$^{-1}$) side-dresses (15N–0P–14K) were applied at 2 week intervals for 8 weeks after seeding. Single applications of preplant (bensulide), preemergence (ethalfluralin), and postemergence (sethoxydim) herbicides were used to control weeds. Insect pests including cucumber beetle (*Diabrotica undecimpunctata*) and squash bug (*Anasa tristis*) were controlled with carbaryl, endosulfan, esfenvalerate, and permethrin (18 applications in 1998; 10 in 1999). Powdery mildew and other foliar diseases were controlled with thiophanate-methyl, chlorothalonil, mefenoxam, and myclobutanil (12 applications in 1998; 13 in 1999). Overhead irrigation was applied to supplement rainfall and provided a total of about 1 inch/week (2.54 cm/week) until harvest. Two honey bee (*Apis mellifera*) hives (25,000+ bees/colony) located near the fields provided pollination. Fruit were harvested 16 Sept. 1998 [92 d after planting (DAP)] and 4 Oct. 1999 (105 DAP). Harvest was delayed in 1999 due to Hurricane Floyd.

**YIELD.** For the large pumpkins, all fruit within plots were individually counted and weighed at harvest to calculate mean fruit weight, number of fruit/acre, and fruit weight/acre. For the miniature pumpkins, fruit were counted individually and bulk-weighed to obtain mean fruit weight, number of fruit number/acre, and fruit weight/acre. Cultivar yield estimates are presented as whole-acre plantings; calculations did not include field space for drive alleys.

**FRUIT CHARACTERISTICS.** Six (1998) and eight (1999) fruit per plot from each of the large pumpkins and ten (1998) and eight (1999) fruit per plot from each of the miniature pumpkins were selected to compare fruit characteristics. Suturing (degree of ribbing on fruit exterior) was rated as 0 = no sutures, 1 = minimal sutures, 2 = light sutures, 3 =moderate sutures, or 4 = heavy sutures. Stem color was rated as 1 = no green, 2 = yellowish-green, 3 = medium green, 4 = dark green, or 5 = solid, dark green. Rind (fruit exterior) color was rated as 1 = light orange, 2 = medium orange, or 3 = dark orange. Stem length was measured (inches) from the stem base (joining the fruit) to the stem top (attachment point to vine). Stem diameter was measured 1 inch above the base of the stem using calipers. Fruit shape was classified as either round (spherical fruit shape), tall (horizontally compressed), or squat (vertically compressed).

While market surveys are needed to generate consumer preferences, we believe these fruit characteristics are important in overall consumer attraction to pumpkins. For example, limited suturing may be preferable for jack o' lantern carving, but well-formed sutures may be an attractive feature for some holiday displays. A solid green stem

**Table 2. Seed source, mean fruit weight, yield, number of fruit/acre, degree of suturing, stem and rind color, stem length and diameter, and fruit shape for 15 miniature pumpkin cultivars grown in eastern North Carolina.[z]**

| Cultivar | Seed source[y] | Year[x] | Individual fruit wt (lb ± SD) | Fruit yield (lb/acre)[w] | Fruit/acre (no.) | Suture[v] | Stem color[u] | Stem length (inches)[t] | Stem diam (inches)[s] | Rind color[r] | Fruit shape description[q] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Touch of Autumn | SD | 99 | 2.1 | 76,980 | 36,300 | 1.5 | 3.5 | 2.5 | 0.9 | 1.2 | Round |
| Lil' Pump-ke-mon | HM | 98, 99 | 0.9 | 33,235 | 35,392 | 4.0 | 3.3 | 2.6 | 0.5 | var [p] | Squat |
| HMX 5682 | HM | 98, 99 | 0.9 | 33,170 | 33,396 | 1.0 | 3.9 | 2.4 | 0.6 | 1.8 | Round |
| Jack-Be-Quick | RP | 99 | 0.6 | 8,120 | 21,417 | 1.0 | 2.0 | 0.9 | 0.2 | 2.0 | Squat |
| Lil' Ironsides | HM | 98, 99 | 1.8 | 35,965 | 21,398 | 1.6 | 2.4 | 2.8 | 0.6 | 1.9 | Round |
| Pik-A-Pie | RP | 99 | 4.5 | 42,800 | 18,876 | 2.6 | 2.9 | 3.5 | 1.2 | 2.0 | Round |
| Lil' Goblin | HM | 98, 99 | 1.3 | 24,240 | 18,513 | 0.6 | 2.8 | 2.5 | 0.7 | 1.2 | Tall |
| Trickster | RP | 98, 99 | 2.4 | 41,225 | 15,972 | 2.2 | 2.8 | 5.7 | 0.8 | 2.7 | Round |
| Spooktacular | RP | 98, 99 | 2.6 | 37,025 | 13,522 | 1.7 | 2.6 | 4.4 | 0.7 | 2.0 | Round |
| Peek-A-Boo | RP | 98, 99 | 3.4 | 44,685 | 13,160 | 2.8 | 1.8 | 5.3 | 1.0 | 2.3 | Tall |
| EXT 4612297 | SV | 98, 99 | 4.6 | 50,420 | 10,890 | 1.2 | 2.2 | 3.0 | 0.8 | 1.2 | Round |
| Baby Pam | RP | 98, 99 | 2.0 | 22,185 | 10,527 | 1.6 | 2.1 | 5.0 | 1.3 | 2.4 | Round |
| Mystic Plus | HM | 98, 99 | 2.4 | 33,040 | 8,258 | 2.3 | 3.2 | 5.3 | 1.5 | 3.0 | Round |
| Mystic | HM | 98, 99 | 3.7 | 26,375 | 6,898 | 1.4 | 2.0 | 4.3 | 1.2 | 2.5 | Round |
| Progold 100 | AC | 99 | 3.0 | 15,640 | 5,445 | 1.0 | 2.3 | 1.9 | 0.4 | 1.0 | Round |
| LSD ($P < 0.05$) [z] | | | 0.6 | 23,170 | 18,560 | 0.6 | 0.6 | 2.9 | 0.8 | 0.6 | |

[z]Values are the means of six (1998 and 1999), four (1998), or two (1999) replications. Least significant difference (LSD) values are applicable to cultivars tested in both years only. Cultivars are ranked by number of fruit/acre.
[y]Seed source: AC = Abbott and Cobb (Feasterville, Pa.), HM = Harris Moran (Modesto, Calif.), RP = Rupp Seed (Wauseon, Ohio), SD = Seeds by Design (Willows, Calif.), and SV = Seminis Vegetable Seed (Oxnard, Calif.).
[x]98 = 1998 and 99 = 1999.
[w]1 lb/acre = 1.12 kg·ha$^{-1}$.
[v]Suture (degree of exterior fruit ribbing) rating: 0 (no sutures); 1 (minimal sutures); 2 (light sutures); 3 (moderate sutures); 4 (heavy sutures).
[u]Stem color rating: 1 (no green); 2 (yellowish-green); 3 (medium green); 4 (dark green); 5 (solid, dark green).
[t]1 inch = 2.54 cm.
[s]Stem diameter measured 1 inch above stem base using calipers.
[r]Rind color (intensity of orange) rating: 1 = light orange, 2 = medium orange, and 3 = dark orange.
[q]General fruit shape: round (spherical), tall (horizontally compressed), or squat (vertically compressed).
[p]Rind coloration for 'Lil' Pump-ke-mon' was variable (green, white, orange, and yellow banding).

indicates recent harvest as well as good overall health and attractiveness of the fruit. Dark orange rinds may be preferable over lighter hues, and long, thick stems make handling fruit easier and may be more attractive than short, thin stems.

**PREHARVEST DECAY, MILDEW, VIRUSES, AND EDEMA (1999 ONLY).** At harvest, fully and partially decayed fruit were quantified for each plot. The causal agent of decay was identified as either *Sclerotium rolfsii* (southern blight) or as "undetermined" if no singularly identifiable pathogen was present or verifiable. This happened when the fruit was in advanced decay from which pathogen isolation and identification was not possible. The percentages of fruit damaged by *S. rolfsii*, undetermined pathogen(s), and their sum (total preharvest decay) were calculated based on the ratio of the number of decaying fruit/plot to the total number of fruit/plot. Decaying fruit were omitted from marketable yield calculations.

While a vigorous fungicide spray program was used to control foliar diseases, we quantified the presence and scored the severity of downy and powdery mildew infection in each plot on a single observation date (17 Aug. 1999; 58 DAP). A scoring system of 0 to 3 was used, where 0 = no plots affected, 1 = one plot infected, 2 = two plots infected or one plot with heavy infection, and 3 = two or more plots with heavy infection.

The incidence and severity of foliar viral symptoms for both large (17 Aug. 1999) and miniature (18 Aug. 1999) cultivars were also evaluated. Incidence was the visual estimation of the percentage of foliage in each plot exhibiting mosaic symptoms. Mosaic symptoms were recognized as angular, sharply bordered pattern of light and dark areas on leaves, typically delimited by small leaf veins. The severity of virus symptoms on foliage was rated from 0 to 10, where 0 = no symptom; 3 = moderate mosaic symptoms; 7 = severe shoestringing and/or blistering (striking narrowing of the newest foliage and/or dark green puckering of leaf tissue) on some vines; and 10 = all affected foliage with severe symptoms. Leaf samples from selected cultivars were sent to Asgrow-SVS (Oxnard, Calif.) and assayed using ELISA (enzyme-linked immunosorbent assay) for the presence of cucumber mosaic virus (CMV), papaya ringspot virus (PRSV), squash mosaic virus (SMV), watermelon mosaic virus (WMV), and zucchini yellow mosaic virus (ZYMV).

The incidence (percentage of fruit exhibiting signs of viral infection) and severity (degree of viral symptoms) of virus symptoms on fruit at harvest were evaluated for each cultivar. Virus symptoms on fruit were described as green to brown, blotchy discoloration (color breaking) and lumpiness of the fruit exterior. Severity was rated from 0 to 10, where 0 = no symptom, 3 = moderate discoloration, 7 = severe discoloration, and 10 = discoloration of entire fruit surface. Severity ratings of 5 or less were classified as marketable, and ratings of 6 or higher were classified as unmarketable and omitted from yield calculations. Correlation analyses were conducted to detect possible relationship(s) between virus incidence and/or severity on foliage to virus incidence and/or severity on fruit. Correlation data were analyzed on a replication basis: virus data collected on fruit from 'Aspen', replication 1, were evaluated in relation to foliar virus data collected for 'Aspen', replication 1.

The number and percentage of fruit with edema were quantified for each cultivar. Although the severity of edema was not scored, individual fruit with severe edema (grossly unattractive fruit) were omitted from yield calculations.

**POSTHARVEST FRUIT DECAY.** Cultivars were compared for susceptibility to postharvest fruit decay using six (1998) and eight (1999) fruit/plot for large pumpkins and ten (1998) and eight (1999) fruit/plot for miniature pumpkins. After harvest, asymptomatic and marketable fruit were placed in the near-full shade of a small pine tree grove on the Research Station. Fruit were placed directly onto pine needle litter that was 2 to 3 inches (5.1 to 7.6 cm) thick such that they sat upright (stem on top) and did not touch one another. The site was visited 9 times in 1998 and 8 times in 1999 at about 7-d intervals [9, 15, 21, 28, 35, 42, 50, 56, and 63 d after harvest (DAH) in 1998; and 8, 14, 21, 28, 36, 42, 49, and 56 DAH in 1999] to determine the number and types of fruit decay. Standard diagnostic procedures were used to determine primary causal agents (Zitter et al., 1996). The postharvest decay data presented here are a summary of two preliminary reports (Holmes et al., 1999; 2000).

**STATISTICAL ANALYSIS.** The experiments were randomized complete blocks with four replications in both years, with the exception of the 1999 miniature pumpkin evaluations in which field space limitations allowed only two replications. Analysis of variance (PROC GLM), mean separations (PROC LSD), and correlation analyses (PROC CORR) were performed with SAS version 6.12 (SAS Institute, Cary, N.C.). Least significant difference (LSD) tests were performed on cultivars that were grown in both years; data from cultivars evaluated in only 1 year were included for comparison purposes only.

## Results and discussion

**YIELDS OF LARGE PUMPKINS.** Mean fruit weight, yield (fruit weight/acre), and number of fruit/acre varied by cultivar ($P < 0.01$), and by year for cultivars tested in both years ($P < 0.01$) (Table 1). 'SVT 4613367', 'Autumn Gold', 'Gold Standard', 'Gold Fever', 'Merlin', and 'Magic Lantern' were the highest yielding cultivars with 2,860 or more fruit/acre (7,067 fruit/ha), indicating they are more adapted to eastern North Carolina and similar southeastern U.S. growing conditions than the other cultivars we tested. 'SVT 4613367' and 'Gold Standard' were only evaluated in 1 year, so yield consistency for these two cultivars was not fully determined. Among the top six producers, mildew-resistant 'Merlin' and 'Magic Lantern' both had the highest mean fruit weights [12.7 lb/fruit (5.76 kg/fruit)] and fruit yield [greater than 36,600 lb/acre (41,022 $kg \cdot ha^{-1}$)]. Cultivars producing less than 1,300 fruit/acre (3,212 fruit/ha) were 'Howden', 'Gold Rush', 'Gold Strike', and 'Progold 200'. 'Howden' has been the standard cultivar recommended and grown in North Carolina, yet our results indicate there are many pumpkin cultivars better adapted to eastern North Carolina conditions. Low yields for 'Howden', and possibly others, may be due to the negative effect high-temperatures have on fruit set (Wien et al., 1998; 2002). Cultivars tested in both years yielded better in 1999 than in 1998 (data not shown), possibly due to soil type differences between years (sandy 1998 versus loamy 1999).

**FRUIT CHARACTERISTICS OF LARGE PUMPKINS.** There were no statistical differences between years for fruit characteristics of cultivars common to both years for the large pumpkins (all tests, $P > 0.05$). These data were therefore combined (Table 1). Cultivars

that were evaluated in only 1 year are indicated.

Most of the cultivars produced round fruit, with light to moderate sutures (ratings 1.5 to 3.0), medium to dark green stem colors (rating 3 to 4), medium to dark orange rinds (rating 2 to 3), with stem lengths and diameters of 5 and 2 inches (12.7 and 5.1 cm) or more, respectively. Notable exceptions were the tall-shaped fruit produced by 'Autumn King', 'Gold Standard', 'Jumping Jack', 'Mother Lode', 'SVT 4613367' and 'SVT 4622837'. 'EX 4622827', 'Merlin', and 'Progold 510' had the heaviest sutures (3.4 to 3.7), while the virus-resistant cultivars ('SVT') had light sutures (rating 1.5 to 1.6). 'Jack of all Trades' and 'Tom Fox' had the lightest stem colors (yellowish-green, rating 2.4). Light orange rind colors (rating 2 or less) were found for 'Autumn King', 'Frosty', 'Jack of all Trades', 'Progold 200', and 'SVT 4622837'. All of the large pumpkins we evaluated had average stem lengths and diameters that made for good handles (5 inches or longer and 2 inches or thicker). The preferences for fruit characteristics described here are a matter of individual consumer preference.

**YIELDS OF MINIATURE PUMPKINS.** Mean fruit weight, yield (fruit weight/acre), and number of fruit/acre varied by cultivar ($P < 0.01$), and by year for cultivars tested in both years ($P < 0.01$) (Table 2). 'Touch of Autumn', 'Lil' Pump-ke-mon', and 'HMX 5682' were the highest yielding cultivars [over 33,000 fruit/acre (81,542 fruit/ha) each], indicating they are more adapted to eastern North Carolina and similar southeastern U.S. growing conditions than the other cultivars tested. Of these top three producers, 'Touch of Autumn' had the heaviest fruit [2.1 lb/fruit (0.95 kg/fruit)] and greatest yield [76,980 lb/acre (86,282 kg·ha$^{-1}$)]. However, this cultivar was evaluated in only 1 year, so yield consistency was not fully determined. Cultivars producing less than 10,000 fruit/acre (24,710 fruit/ha) were 'Mystic', 'Mystic Plus', and 'Progold 200'. As with the large pumpkins, the miniature pumpkins tested in both years yielded better in 1999 than in 1998 (data not shown), possibly due to soil type differences between years (sandy in 1998 versus loamy in 1999).

**FRUIT CHARACTERISTICS OF MINIATURE PUMPKINS.** There were no statistical differences between years for fruit characteristics of cultivars common to both years for the miniature pumpkins (all tests, $P > 0.05$). These data were therefore combined (Table 2). Cultivars that were evaluated in only 1 year are indicated.

Most miniature pumpkins tended to be round in shape. The exceptions were 'Lil' Goblin' and 'Peek-A-Boo' which had tall-shaped fruit, and 'Lil' Pump-ke-mon' and 'Jack-Be-Quick' which produced squat-shaped fruit. In contrast to the large pumpkins, the miniature pumpkins tended to have lighter sutures (rating 1 to 2), with more yellowish-green stems (rating 2 to 3), rinds of lighter orange (rating 1.3 to 2.0), and had shorter [3.6 inches (9.14 cm)] and thinner [0.8 inch (2.03 cm)] stems. The notable exception was 'Lil' Pump-ke-mon', which had the deepest sutures (rating 4.0) and a mixed-color rind of white, orange, green, and yellow longitudinal (stem to flower scar) bands. The cultivars that produced miniature pumpkins closely resembling the appearance of large pumpkins were 'Mystic Plus', 'Peek-a-Boo', 'Pik-a-Pie', and 'Trickster', with their dark orange rinds and moderate suturing. The preferences for fruit characteristics described here are a matter of individual consumer preference.

**PREHARVEST FRUIT ROT.** Total preharvest fruit decay varied significantly between cultivars ($P < 0.05$ for both large and miniature pumpkins), suggesting that the fruit of some cultivars may be less susceptible to preharvest pathogen loss (Table 3). For example, no preharvest fruit was lost from 'Howden', whereas 'Jumping Jack' and 'Tom Fox' were the most susceptible to preharvest fruit decay (22% or more fruit lost before harvest). For most large cultivars, the causal agent for fruit rot was undetermined since many of these diseased fruit were in advanced decay. While there were no statistical differences between cultivars in terms of susceptibility to southern blight, 'Gold Rush', 'Howdy Doody', and 'Progold 200' appeared to be more susceptible, as 50% or more of their total number of decaying fruit were attributed to this disease.

In general, the miniature pumpkins were more susceptible to preharvest decay than the large pumpkins, but none of the miniature pumpkins appeared to have been lost to southern blight. Thus, the causal agent(s) for all of the miniature pumpkin fruit decay was recorded as undetermined. 'Baby Pam', 'EXT 4612297', 'Mystic', 'Mystic Plus', and 'Trickster' had low (less than 5%) incidence of fruit decay, whereas most cultivars ranged between 10% to 20%. 'Lil' Goblin' and 'Peek-A-Boo' appeared to be the most susceptible to preharvest decay (22% or more fruit lost before harvest).

Spot-application of pesticides to and under developing pumpkin fruit to prevent preharvest infection and decay is logistically impractical. Selecting cultivars that are less prone to preharvest decay appears to be the best remedy for this type of production loss. Growing pumpkins on plastic mulch might also reduce fruit rot, but this has not been tested.

**FOLIAR DISEASES.** Downy (DM) and powdery mildew (PM) were not observed on 16 of the 26 large pumpkin cultivars and 10 of the 15 miniature pumpkin cultivars (Table 3), suggesting that the fungicide spray program we implemented provided some suppression of foliar diseases. Of the large pumpkins on which both DM and PM were observed, 'Gold Rush', 'Howden', and 'Progold 510' each appeared to be the most susceptible, where either 50% of their respective plots had both pathogens, or one or more of their plots had severe infections of both pathogens. In addition, 'Gold Strike', 'Jumping Jack', and 'Mother Lode' had high levels of DM, and 'Tom Fox' had high levels of PM. For the miniature pumpkins, 'EXT 4612297', 'Lil' Goblin', and 'Lil' Ironsides' appeared to be the most susceptible to DM and PM.

While observations on DM and PM prevalence were only conducted in 1 year of our study, the results suggest that pumpkin cultivars vary in susceptibility to these diseases, as was found by Keinath and DuBose (2000). Therefore, pumpkin production under high humidity conditions like the southeastern U.S. requires a vigorous fungicide spray program and/or foliar disease-resistant cultivar selection.

**FOLIAR AND FRUIT VIRUS SYMPTOMS.** All large pumpkin foliage showed moderate to heavy virus incidence (31% to 74% of foliage with visible virus symptoms), with the exception of the virus-resistant cultivar, 'SVT 4613367' (2% of foliage) (Table 3). Foliage from 12 of the 25 nontransgenic cultivars had less than 50% virus incidence, with a mean severity value of 2.1. All leaf samples from selected cultivars that ranged in symptom severity from minimal to severe tested positive for one or more

of the following viruses: PRSV, WMV, and ZYMV. The transgenic WMV- and ZYMV-resistant cultivar, 'SVT 4613367', tested positive for PRSV.

For the miniature pumpkins, no virus incidence was observed on the virus-resistant cultivar, 'EXT 4612297'; however, this cultivar did test positive for PRSV when assayed (Table 3). All other cultivars exhibited varying degrees of foliar virus incidence (10% to 66%). Most cultivars had 30% or more of the foliage exhibiting some virus symptoms. Severity of foliar virus symptoms on the miniature pumpkins ranged from 0 for 'EXT 4612297' to 4.0 for 'Mystic Plus' and 'Spooktacular'.

Only 1% of 'SVT 4613367' fruit exhibited minor virus symptoms, while between 4% ('Merlin') and 33% ('Gold Strike') of fruit from the non-transgenic large pumpkins exhibited viral symptoms that ranged in severity from minor (1.0 for 'Appalachian') to moderate (4.6 for 'Early Autumn'). 'Gold Strike' was the only cultivar that produced significantly more fruit

**Table 3. Preharvest fruit rot, foliar disease, foliar and fruit virus symptoms, and fruit edema for large and miniature pumpkins evaluated in 1999 in eastern North Carolina.[z]**

| Cultivar | Seed source[w] | Preharvest fruit rot (%)[y] | | | Foliar disease[x] | | Virus symptom incidence (severity) | | Virus(es) detected[t] | Edema[s] (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | SB | UD | Total | DM | PM | Foliage[v] | Fruit[u] | | |
| Large Pumpkins | | | | | | | | | | |
| Aladdin | HM | 2 | 5 | 7 | 0 | 0 | 49 (2.0) | 11 (3.0) | --- | 12 |
| Appalachian | PS | 5 | 13 | 18 | 0 | 0 | 36 (1.0) | 6 (1.0) | PRSV | 15 |
| Aspen | HL | 5 | 14 | 19 | 0 | 0 | 34 (1.9) | 7 (2.5) | --- | 13 |
| Autumn Gold | NV | 4 | 9 | 14 | 0 | 0 | 48 (1.5) | 9 (3.9) | PRSV | 0 |
| Autumn King | SD | 0 | 8 | 8 | 0 | 0 | 59 (3.4) | 10 (2.0) | --- | 13 |
| Early Autumn | NV | 2 | 3 | 5 | 0 | 1 | 55 (3.5) | 23 (4.6) | --- | 24 |
| EX 4622827 | SV | 1 | 14 | 15 | 0 | 0 | 66 (2.0) | 9 (2.2) | PRSV | 6 |
| Frosty | HL | 3 | 10 | 13 | 0 | 0 | 31 (1.4) | 13 (2.8) | --- | 5 |
| Gold Fever | RP | 1 | 3 | 4 | 0 | 0 | 44 (2.4) | 19 (2.5) | --- | 4 |
| Gold Rush | RP | 5 | 5 | 10 | 2 | 2 | 71 (1.9) | 19 (1.6) | --- | 0 |
| Gold Standard | RP | 1 | 9 | 10 | 1 | 0 | 61 (1.9) | 10 (3.5) | --- | 2 |
| Gold Strike | RP | 2 | 15 | 16 | 2 | 0 | 48 (2.4) | 33 (2.6) | PRSV, ZYMV | 5 |
| Happy Jack | PS | 0 | 9 | 9 | 1 | 0 | 32 (2.0) | 11 (2.5) | - | 3 |
| Howden | HM | 0 | 0 | 0 | 3 | 3 | 46 (1.9) | 19 (4.0) | PRSV, WMV | 9 |
| Howdy Doody | RP | 2 | 2 | 4 | 0 | 0 | 52 (1.2) | 11 (1.6) | --- | 1 |
| Jack of all Trades | HL | 0 | 7 | 7 | 0 | 0 | 35 (3.0) | 23 (1.9) | PRSV, WMV, ZYMV | 15 |
| Jumping Jack | HL | 6 | 16 | 22 | 2 | 0 | 54 (3.1) | 22 (2.9) | --- | 3 |
| Magic Lantern | HM | 2 | 7 | 9 | 0 | 0 | 54 (1.5) | 24 (4.1) | --- | 9 |
| Merlin | HM | 0 | 11 | 11 | 0 | 0 | 62 (1.5) | 4 (4.5) | --- | 13 |
| Mother Lode | RP | 1 | 6 | 7 | 2 | 0 | 40 (1.9) | 11 (1.7) | --- | 2 |
| Progold 200 | AC | 3 | 0 | 3 | 0 | 0 | 69 (2.0) | 19 (2.6) | --- | 0 |
| Progold 510 | AC | 2 | 10 | 12 | 3 | 3 | 58 (2.4) | 14 (2.5) | --- | 8 |
| Racer | JS | 1 | 5 | 6 | 0 | 0 | 64 (2.1) | 16 (2.0) | --- | 5 |
| REX 38040 | RP | 1 | 9 | 10 | 0 | 0 | 32 (1.6) | 13 (2.4) | --- | 2 |
| SVT 4613367 | SV | 1 | 0 | 1 | 0 | 0 | 2 (0.4) | 1 (2.0) | PRSV | 2 |
| Tom Fox | JS | 2 | 25 | 27 | 0 | 2 | 74 (2.6) | 28 (2.7) | --- | 8 |
| LSD ($P < 0.05$) | | NS | 25 | 18 | --- | --- | 29 (0.9) | 29 (2.4) | --- | 20 |
| Miniature Pumpkins | | | | | | | | | | |
| Baby Pam | RP | 0 | 4 | 4 | 0 | 0 | 52 (3.8) | 0 | --- | 0 |
| EXT 4612297 | SV | 0 | 0 | 0 | 1 | 2 | 0 | 0 | PRSV | 0 |
| HMX 5682 | HM | 0 | 12 | 12 | 0 | 0 | 15 (2.2) | 14 (2.0) | --- | 0 |
| Jack-Be-Quick | RP | 0 | 12 | 12 | 1 | 0 | 41 (1.9) | 7 (2.0) | --- | 2 |
| Lil' Goblin | HM | 0 | 31 | 31 | 1 | 2 | 46 (1.2) | 66 (4.4) | --- | 0 |
| Lil' Ironsides | HM | 0 | 10 | 10 | 1 | 2 | 22 (2.6) | 14 (4.0) | --- | 0 |
| Lil' Pump-ke-mon | HM | 0 | 12 | 12 | 0 | 0 | 10 (1.8) | 37 (2.1) | --- | 0 |
| Mystic | HM | 0 | 5 | 5 | 0 | 0 | 66 (3.1) | 0 | --- | 0 |
| Mystic Plus | HM | 0 | 4 | 4 | 0 | 0 | 64 (4.0) | 46 (1.0) | --- | 0 |
| Peek-A-Boo | RP | 0 | 22 | 22 | 0 | 0 | 28 (3.2) | 5 (1.0) | --- | 0 |
| Pik-A-Pie | RP | 0 | 19 | 19 | 0 | 1 | 46 (1.8) | 0 | --- | 8 |
| Progold 100 | AC | 0 | 13 | 13 | 0 | 0 | 46 (2.5) | 8 (7.0) | --- | 7 |
| Spooktacular | RP | 0 | 10 | 10 | 0 | 0 | 34 (4.0) | 13 (1.4) | --- | 5 |
| Touch of Autumn | SD | 0 | 12 | 12 | 0 | 0 | 45 (1.2) | 16 (3.6) | --- | 14 |
| Trickster | RP | 0 | 4 | 4 | 0 | 0 | 30 (1.2) | 5 (1.0) | --- | 5 |

[z]Values are the means of four (large pumpkins) or two (miniature pumpkins) replications. Cultivars are listed alphabetically. No least significant difference (LSD) analysis was performed on data from miniature pumpkins, as only two replications were possible.
[y]Percent fruit rot at harvest. Fruit rot caused by southern blight (SB) or undetermined (UD) pathogen(s). Total percent fruit rot is the sum of both of categories.
[x]DM = downy mildew and PM = powdery mildew. Scores are 0 = no plots infected, 1 = one plot infected, 2 = two plots infected or one plot with heavy infection, and 3 = two or more plots with heavy infection.
[w]Seed source: AC = Abbott and Cobb (Feasterville, Pa.), HL = Hollar and Co. (Rocky Ford, Colo.), HM = Harris Moran (Modesto, Calif.), JS = Johnny's Selected Seeds (Winslow, Maine), NV = Novartis (Boise, Idaho), PS = Petoseed (Saticoy, Calif.), RP = Rupp Seed (Wauseon, Ohio), SD = Seeds by Design (Willows, Calif.), and SV = Seminis Vegetable Seed (Oxnard, Calif.).
[v]Data collected on 17 Aug. 1999. Incidence is percentage of foliage with viral symptoms. Severity scale: 1 (minor) to 10 (severe).
[u]Data collected on 4 Oct. 1999. Incidence is percentage of fruit with viral symptoms. Severity scale: 1 (minor) to 10 (severe).
[t]Viruses: PRSV = papaya ringspot virus, WMV = watermelon mosaic virus, and ZYMV = zucchini yellow mosaic virus. Dashes indicate that no sample was taken from cultivar. Virus presence determined with enzyme-linked immunosorbent assay (ELISA) analyses by Asgrow-SVS (Oxnard, Calif.).
[s]Percentage of fruit with edema (callused, wart-like growths on fruit exterior).
[NS]Nonsignificant at $P = 0.05$.

with visible viral symptoms than the other cultivars. Cultivars with consistently minor fruit discoloration from viral infection (severity rating less than 2.0) were 'Appalachian', 'Gold Rush', 'Howdy Doody', 'Jack of all Trades', and 'Mother Lode'.

For miniature pumpkins, no virus symptoms were visible on the fruit of 'Baby Pam', 'Mystic', or 'Pik-A-Pie', even though virus symptoms were observed on 46% or more of their foliage (Table 3). The other nontransgenic miniature pumpkins ranged from 5% of fruit with minor discoloration ('Peek-A-Boo' and 'Trickster') to 66% of fruit with moderate discoloration ('Lil' Goblin'). No foliar or fruit virus symptoms were observed on the transgenic, virus-resistant cultivar, 'EXT 4612297'. While only 8% of 'Progold 100' fruit had visible virus symptoms, this cultivar was the most susceptible to severe discoloration from viral infection (severity 7.0). Since these large and miniature pumpkins are used in holiday displays and not consumed, fruit with virus markings are sometimes marketed as being naturally decorated, which may increase their appeal to some customers.

Correlation analyses revealed no obvious relationships(s) between virus incidence and/or severity on foliage to virus incidence and/or severity on fruit for either the large or miniature pumpkins. The absence of a positive relationship between foliar and fruit virus symptoms suggests that prevalence and severity of foliar symptoms is not a good indicator of the prevalence and severity of fruit symptoms.

Because virus data were collected only in 1 year, we could not determine if viruses negatively affected yield with respect to the number and weight of fruit produced. However, the adverse effect of viruses on yield has been previously documented on summer squash and other cucurbits (Schultheis and Walters, 1998; Snyder et al., 1993; Zitter et al., 1996).

**EDEMA.** Susceptibility of pumpkin to edema was cultivar-dependent (Table 3). This condition usually occurred at the soil-fruit contact point. Most of the large cultivars produced fruit with less than 10% edema, and no edema was found on 'Autumn Gold', 'Gold Rush', and 'Progold 200' fruit. 'Early Autumn' had significantly more fruit with edema (24% of the fruit affected) than the other cultivars.

The miniature pumpkins tended to be less prone to edema than the large pumpkins, as nine of the 14 miniature pumpkins produced fruit with no edema. The notable exception was 'Touch of Autumn' with 14% of the fruit affected. 'Jack-Be-Quick', 'Pik-A-Pie', 'Progold 100', 'Spooktacular', and 'Trickster' each had edema on 1% to 10% of the fruit produced.

While we did not score the severity of edema, individual fruit with severe cases were unattractive, considered unmarketable, and omitted from yield estimates. Because the cause of this condition is unknown, it is impossible to recommend strategies to avoid edema, but we recommend that growers select cultivars that seem less susceptible to edema. In mild cases of edema, deformation of the fruit exterior may be minimal enough to be acceptable to consumers.

**POSTHARVEST FRUIT ROT.** An increase in postharvest fruit decay from 1998 to 1999 was found for most of the large pumpkins and for all of the miniature pumpkins (Table 4). This increase is possibly due to differences in overall environmental conditions, particularly the heavy precipitation and delayed harvest following Hurricane Floyd during the 1999 postharvest study.

Cultivars varied in their susceptibility to postharvest fruit decay ($P < 0.01$). The highest level of decay occurred in the first two weeks of storage for large pumpkins in both years, whereas decay levels for the miniature pumpkins were generally uniform over time. By the end of the evaluation period (56 to 63 DAH), total percent postharvest fruit decay ranged from 0% ('Gold Strike' and 'Lil' Pump-ke-mon' in 1998), to less than 10% ('REX 38040' in both years), to 80% or more ('Lil' Goblin' in both years). For most cultivars, average fruit decay was 15% to 40% during the postharvest evaluation period.

In 1998, fruit rots were caused by *Xanthomonas campestris* pv. *cucurbitae* (62%), *Colletotricum orbiculare* (15%), and *Fusarium* spp. (15%). There were a few fruit with obvious cracks and insect injury (e.g., small holes in the rind) that may have lead to decay of about 5% of the rots. In 1999, fruit rots were primarily *Colletotricum orbiculare* (49%) and *Fusarium* spp. (31%). *Fusarium* was more prevalent in the first four evaluations while *C. orbiculare* became more predominant over time. Other fruit rotting organisms identified were *Sclerotium rolfsii* (3%), *Pythium* spp. (1.5%), *Phytophthora nicotianae* (6%), *Geotrichum candidum* (3%), and *Gliocladium roseum* (1.5%). About 10% of rots were classified as soft rots if a causal agent was not successfully isolated. *Cladosporium* sp. was detected on 6% of rotted fruit and usually in association with *Fusarium* spp. Pathogenicity of *P. nicotianae* isolates was confirmed by puncture-inoculating pumpkin fruit and fulfilling Koch's postulates. This was the first report of *P. nicotianae* as a pathogen of pumpkin (Holmes, 2000).

Pumpkin cultivars less prone to postharvest fruit decay produce fruit with a longer shelf life. Longevity of fruit for holiday displays may be a selling point that growers can use to increase a pumpkin's marketability.

## Conclusions

In general, the pumpkin yields we obtained under eastern North Carolina conditions were greater than the yields of the same or similar cultivars ('Howden') grown under southeastern coastal plain conditions (Keinath and DuBose, 2000; Wien et al., 1998; 2002). Our studies suggest that implementing thorough cultural practices together with selecting regionally adapted cultivars can lead to productive and potentially profitable pumpkin crops for growers under these or similar southeastern U.S. conditions.

While many cultivars appeared to have some degree of adaptability to our area, we recommend the following four large pumpkins: 'Autumn Gold', 'Gold Fever', 'Magic Lantern', and 'Merlin'; and three miniature pumpkins: 'Lil' Pump-ke-mon', 'HMX 5682', and 'Lil' Ironsides', as potential high-yielding cultivars of quality pumpkins for production in eastern NC and similar areas. These recommendations are based on 2-year yield performance under the various disease pressures during production. While some of the cultivars we recommend exhibited fairly high levels of postharvest decay (up to 30% for 'Autumn Gold'), the length of our postharvest fruit decay study was longer than the typical shelf life of a pumpkin used for Halloween and holiday displays. 'Gold Standard' (large),'SVT 4613367' (large), 'Touch of Autumn' (miniature), and 'Jack-Be-Quick' (miniature) also produced high yields, but are recommended on a trial basis only as they were tested in only 1 year. 'Lil' Pump-ke-mon' has a unique rind pattern which growers should also

be aware of when selecting cultivars producing miniature pumpkins. Pumpkin growers can perhaps use the fruit characteristics we describe here as a quick index for selecting various fruit characteristics to suit particular market(s).

**Table 4. Susceptibility of large and miniature pumpkins to postharvest fruit decay in eastern North Carolina.[z]**

| Cultivar | Seed source[x] | Fruit decay (%)[y] 1998 | 1999 | Mean[w] |
|---|---|---|---|---|
| Large pumpkins | | | | |
| Aladdin | HM | 17 | 25 | 21 |
| Appalachian | PS | --- | 12 | --- |
| Aspen | HL | 20 | 60 | 40 |
| Autumn Gold | NV | 38 | 22 | 30 |
| Autumn King | SD | --- | 31 | --- |
| Early Autumn | NV | 4 | 44 | 24 |
| EX 4622827 | SV | --- | 44 | --- |
| Frosty | HL | 12 | 25 | 18 |
| Gold Fever | RP | 17 | 22 | 20 |
| Gold Rush | RP | 11 | 9 | 10 |
| Gold Standard | RP | --- | 16 | --- |
| Gold Strike | RP | 0 | 16 | 16 |
| Happy Jack | PS | 4 | 62 | 33 |
| Howden | HM | 27 | 28 | 28 |
| Howdy Doody | RP | 8 | 12 | 10 |
| Jack of all Trades | HL | 12 | 28 | 20 |
| Jumping Jack | HL | 41 | 28 | 34 |
| Magic Lantern | HM | 17 | 60 | 38 |
| Merlin | HM | 8 | 31 | 20 |
| Mother Lode | RP | 21 | 25 | 23 |
| Progold 200 | AC | --- | 12 | --- |
| Progold 510 | AC | 21 | 25 | 3 |
| Racer | JS | 41 | 25 | 33 |
| REX 38040 | RP | 8 | 9 | 8 |
| SVT 4613367 | SV | --- | 31 | --- |
| SVT 4622837 | SV | 4 | --- | --- |
| Tom Fox | JS | 8 | 41 | 24 |
| LSD ($P < 0.05$)[v] | | 21 | 32 | 25 |
| Miniature pumpkins | | | | |
| Baby Pam | RP | 31 | 62 | 46 |
| EXT 4612297 | SV | 21 | 38 | 30 |
| HMX 5682 | HM | 18 | 44 | 31 |
| Jack-Be-Quick | RP | --- | 12 | --- |
| Lil' Goblin | HM | 80 | 94 | 87 |
| Lil' Ironsides | HM | 12 | 38 | 25 |
| Lil' Pump-ke-mon | HM | 0 | 31 | 31 |
| Mystic | HM | 8 | 19 | 14 |
| Mystic Plus | HM | 2 | 25 | 14 |
| Peek-A-Boo | RP | 25 | 56 | 39 |
| Pik-A-Pie | RP | --- | 12 | --- |
| Progold 100 | AC | --- | 12 | --- |
| Spooktacular | RP | 22 | 75 | 48 |
| Touch of Autumn | SD | --- | 25 | --- |
| Trickster | RP | 12 | 50 | 31 |
| LSD ($P < 0.05$)[v] | | 20 | --- | --- |

[z]Year values are the means of four (large pumpkins, both years; miniature pumpkins, 1998 only) or two (miniature pumpkins, 1999) replications. Cultivars are listed alphabetically.
[y]Dashes indicate the cultivar evaluation was limited to 1 year.
[x]Seed source: AC = Abbott and Cobb (Feasterville, Pa.), HL = Hollar and Co. (Rocky Ford, Colo.), HM = Harris Moran (Modesto, Calif.), JS = Johnny's Selected Seeds (Winslow, Maine), NV = Novartis (Boise, Idaho), PS = PetoSeed (Saticoy, Calif.), RP = Rupp Seed (Wauseon, Ohio), SD = Seeds by Design (Willows, Calif.), and SV = Seminis Vegetable Seed (Oxnard, Calif.).
[w]Two-year data are the means of eight replications (four in each year) for the large pumpkins, or six replications (four in 1998, two in 1999) for the miniature pumpkins.
[v]LSD = least significant difference tests. No analysis was performed for miniature pumpkins in 1999, as only two replications were possible.

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