Crop Profile for White Potatoes in Delaware

Prepared: September, 2000
Revised: August 14, 2006

General Production Information (1)

- Acres of white potatoes planted in Delaware were 3,300 (2005) and 3,000 (2006)
- Acres of white potatoes harvested were 3,100 (2005) and 2,100 (2006)
- Average yields were 260 CWT (2005) and 240 Cwt. (2006).
- Production values were $806,000 (2005) and $504,000 (2006).

Production Regions

Potatoes can be grown in all three Delaware counties.

Cultural Practices (2, 4)

Potatoes are produced in greater quantities worldwide than any other vegetable. Members of the nightshade, potatoes are related to tomatoes, peppers, and eggplants. The edible portion of the potato plant is the underground tuber that serves as food storage. Potato setting, or tuberization, occurs six to eight weeks after planting, or when the plant is in the early bud stage. In Delaware approximately 5,000 acres of potatoes are grown annually and shipped throughout the eastern United States and Canada. Many good varieties do well in Delaware:

Round Whites - Superior, Kennebec, Haig and Katahdin

Red Potatoes - Norland and Red LaSoda

Russets - Russet Burbank and Belrus

<u>Planting and Spacing</u>
The recommended planting dates for potatoes are March 20 to April 15 in Delaware. Space seed 7 to 12 inches apart in 34- or 36-inch rows. Use close spacing for large, cut seed pieces and wider spacing for whole (B-size) seed. Use close spacing for potatoes to be marketed in 5- and 10-pound consumer packs and for Katahdin and Kennebec, which tend to set few tubers and produce oversize tubers.

<u>Seed-Piece Treatment</u>
Use certified seed. Give seed potatoes a warming-up (65^{o} to 70^{o}F) period of 2 to 3 weeks before planting, to encourage rapid emergence. Plant seed pieces immediately after cutting or store under conditions suitable for rapid healing of

the cut surfaces (60^{o} to 70^{o}F, plus high humidity). Dust seed pieces immediately after cutting. Some fungicide seed-piece treatments are formulated with fir or alder bark. Bark formulations have been effective treatments. Use one of the following:

For *Fusarium spp*.:

- captan--1 lb 7.5D/cwt
- maneb*--1 lb 8D/cwt
- Polyram--1 lb 7D/cwt

For *Fusarium spp. and Rhizoctonia spp*.:

- Maxim--0.5 lb 0.5D/cwt
- Maxim MZ*--0.5 lb/cwt
- MonCoat MZ*--0.75-1 lb 7.5D/cwt
- Tops--1 lb 2.5D/cwt
- Tops MZ*--0.75-1 lb 8.5 D/cwt
- Evolve* (thiophante-methyl, mancozeb and cymoxanil)--0.75 lb/cwt

For aphids, Colorado potato beetle, flea beetle and potato leafhopper:

- Cruiser 5FS
- Tops MZ Gaucho--12 oz/cwt

* Seed-piece fungicides that contain EBDC fungicides or cymoxanil also provide protection against seedborne late blight infections.

WEED CONTROL (4)

Glyphosate--1.5-3.75 lb acid equivalent/A. Apply 3.2 to 8.1 pints per acre Roundup Ultra Max 4SC, 4 to 10 pints per acre Touchdown or 4 to 10 pints per acre Glyphomax Plus in the fall after harvest to control perennial grasses and broadleaf weeds, including quackgrass, field bindweed, Canada thistle, and others. Delay application after harvest to allow for adequate weed regrowth to intercept the spray. Apply before frost to weeds with cold-sensitive foliage. Do not till or mow for 1 week after application.

<u>Emergence/Drag-Off</u>

EPTC--3-4.5 lb/A. Apply 3.4 to 5.1 pints per acre Eptam 7E or 30 to 45 pounds per acre of Eptam 10G at one of the times listed below:

1. Just before planting and disking. This treatment is best for early season control of nutsedge and other weeds, but on plantings before April 1, it may reduce early vigor and yields slightly.
2. Just after "dragging off." Incorporate into soil in one or two cultivations with a spiketooth harrow or similar piece of equipment.
3. Just before first or second cultivation. This treatment is best for late-season control of nutsedge and other weeds.

Do not apply within 45 days of harvest. Primarily controls annual grasses, yellow nutsedge, and a few broadleaf weeds. Use linuron or metribuzin according to recommendations after planting to increase the spectrum of broadleaf weeds controlled.

Linuron--0.4-1 lb/A. Apply 0.8 to 2 pounds per acre Lorox 50DF after planting or before potatoes emerge, but after final drag-off and before grasses are 2 inches tall and broadleaf weeds are 6 inches tall. Primarily controls broadleaf weeds. Tank-mix with Dual Magnum or Prowl, or use in addition to Eptam for preemergence annual grass control. Use lower rates if tank-mixed. Do not plant to crops not on the label for 4 months after treatment.

S-metolachlor--0.96-1.91 lb/A. Apply 1 to 2 pints per acre Dual Magnum 7.62E or Dual II Magnum 7.64E before potatoes emerge, but after final drag-off. Dual Magnum will primarily control annual grasses. Nutsedge (nutgrass, coffeegrass) control may be adequate if weed pressure is light. Tank-mix Dual Magnum with linuron or metribuzin for broadleaf weed control.

Metribuzin--0.38-0.5 lb/A. Apply 0.5 to 0.66 pound per acre Sencor/Lexone 75DF just prior to emergence. If drag-off is practiced, then the application should be made after drag-off. Primarily controls broadleaf weeds. Tank-mix with Dual Magnum or Prowl, or use in addition to Eptam for preemergence annual grass control. Do not apply within 60 days of harvest. Preemergence application to Atlantic and Norland or to any early maturing, smooth, white- or red-skinned potato varieties, may cause crop injury, especially under adverse weather conditions and when higher labeled rates are used.

Pendimethalin--0.5-1.5 lb/A. Apply 1 to 3 pints per acre Prowl 4EC before potatoes emerge. Prowl primarily controls certain broadleaf weeds, including velvetleaf and early season annual grasses, but does not control yellow nutsedge. Combine with Lorox to improve velvetleaf control, or with linuron or metribuzin to improve the control of most other broadleaf weeds.

Postemergence

Rimsulfuron--0.0156 lb/A. Apply 1 ounce per acre Matrix 25DF early postemergence to control many weeds including foxtail species, pigweed species, wild mustard, and wild radish. Common lambsquarter, common ragweed, jimsonweed, morningglory species, and yellow nutsedge may only be suppressed. Tank-mix with reduced rates of metribuzin, following label instructions, to increase the spectrum of weeds controlled. Repeat the application 2 to 4 weeks after the initial spray to improve the suppression or control of common purslane and perennial weeds, such as field and hedge bindweed. Results may be most effective when used following a preemergence residual weed control program. Add nonionic surfactant to be 0.25 percent of the spray solution (1 quart per 100 gallons of spray solution) to improve weed control. DO NOT exceed 2 ounces of Matrix 25DF per acre per year. Rimsulfuron is an ALS inhibitor. Herbicides in this class have a single site of action in susceptible plants. Always use in combination with other herbicides with a different site of action in the plant to prevent the development of resistant weed

populations.

S-metolachlor--1.6 lb/A. Apply 1.67 pints Dual Magnum 7.62E as a directed spray after hilling/at lay-by to provide preemergence control of sensitive weeds for the remainder of the growing season. Emerged weeds will not be controlled. This treatment may be applied in addition to a previous (drag-off) application of Dual Magnum or Dual II Magnum, but do not apply more than 3.6 pints Dual Magnum per acre in one season. Maintain a 40-day preharvest interval between the after hilling/at lay-by application of Dual Magnum and harvest.

Metribuzin--0.25-0.5 lb/A. Apply 0.33 to 0.66 pound per acre Lexone/Sencor 75DF before weeds are 1 inch tall. Primarily controls broadleaf weeds. Apply only if there have been at least three successive sunny days prior to application. Do not use on red-skinned or early maturing, smooth, white-skinned varieties. Treatment may cause some yellowing or minor burn.

Clethodim--0.094-0.125 lb/A. Apply 6 to 8 fluid ounces per acre Select 2EC with oil concentrate to be 1 percent of the spray solution (1 gallon per 100 gallons of spray solution) or 12 to 16 fluid ounces of Selectmax 0.97EC with nonionic surfactant to be 0.25% of the spray solution (1 quart per 100 gallons of spray solution) postemergence to control many annual and certain perennial grasses, including annual bluegrass. Select 2EC will not consistently control goosegrass. The use of oil concentrate with Select 2EC may increase the risk of crop injury when hot or humid conditions prevail. To reduce the risk of crop injury, omit additives or switch to nonionic surfactant when grasses are small and soil moisture is adequate. Control may be reduced if grasses are large or if hot, dry weather or drought conditions occur. For best results, treat annual grasses when they are actively growing and before tillers are present. Repeated applications may be needed to control certain perennial grasses. Yellow nutsedge, wild onion, or broadleaf weeds will not be controlled. Do not tank-mix with or apply within 2 to 3 days of any other pesticide unless labeled as the risk of crop injury may be increased, or reduced control of grasses may result. Observe a minimum preharvest interval of 30 days.

Sethoxydim--0.2-0.4 lb/A. Apply 1 to 2 pints per acre Poast 1.5EC with oil concentrate to be 1 percent of the spray solution (1 gallon per 100 gallons of spray solution) postemergence to control annual grasses and certain perennial grasses. The use of oil concentrate may increase the risk of crop injury when hot or humid conditions prevail. To reduce the risk of crop injury, omit additives or switch to nonionic surfactant when grasses are small and soil moisture is adequate. Control may be reduced if grasses are large or if hot, dry weather or drought conditions occur. For best results, treat annual grasses when they are actively growing and before tillers are present. Repeated applications may be needed to control certain perennial grasses. Yellow nutsedge, wild onion, or broadleaf weeds will not be controlled. Do not tank-mix with or apply within 2 to 3 days of any other pesticide unless labeled, as the risk of crop injury may be

increased, or reduced control of grasses may result. Observe a minimum preharvest interval of 30 days and apply no more than 5 pints per acre in one season.

Postharvest

Paraquat--0.6 lb/A. A Special Local-Needs 24(c) label has been approved for the use Gramoxone Inteon 2SC for postharvest desiccation of the crop in Delaware. Apply 2.4 pints per acre Gramoxone Inteon 2SC as a broadcast spray after the last harvest. Add nonionic surfactant according to the labeled instructions.

INSECT CONTROL (2, 4)

Wireworms

Damage and Life Cycle

Wireworms, the larvae of click beetles (Elateridae), feed on a variety of crop and non-crop plants. Several species of wireworms attack potatoes and can damage seed pieces, roots, and tubers. Most species spend 2 to 4 years in the larval stage, so adults and immatures may be present during the growing season (10). Adults emerge in May or June. Eggs are deposited in the soil in late spring (5). Larvae infest the soil, hollowing out seed pieces, pruning roots, and feeding on developing shoots. This damage makes plants more susceptible to fungal infection and other diseases. Damaged tubers have round entry holes. After 2 to 4 years of development and feeding, mature larvae pupate in the soil before emerging as adults to continue the cycle. Larvae and pupae overwinter deep in the soil (10).

Frequency of Occurrence

Wireworms are considered a major pest problem in potatoes. Populations are often greater in fields previously planted in cereal crops (10). Wireworm populations are also favored by planting into situations with heavy amounts of crop residue, continuous small grains, or a rotation with field corn with no soil insecticide at planting.

Management

Soils can be sampled for wireworms prior to planting in fields that have a history of infestation, or fields previously planted in cereal or sod (10). As a general guideline, a soil insecticide is needed if 5 or more wireworms are found in 20 soil samples.

Chemical Controls

Soil insecticides are the only chemical means for controlling wireworms. They are applied in the spring when the soil temperature at the 6-inch depth is at least 50^{o} F (10^{o} C) and soil moisture is equivalent to that desired for planting. Frequently, the insecticide is applied immediately before or at planting.

Preplant Application

- Mocap--40-60 lb 10G/A. Broadcast and incorporate just before planting.
- Diazinon - A special local needs label (24-C) is in effect in Delaware for the use of diazinon AG500 on white potatoes for the control of wireworms. Apply 2 lb. 50W/A as a preplant broadcast application.

Planting Application

- Bifenthrin - 19.2 fl oz 2EC/A
- Mocap--30 lb 10G/A in the row
- Regent – 0.184-0.22 fl oz 4SC/A in furrow only
- Thimet--8.5-11.3 oz 20G/1000 ft of row (light soils) or 13-17.3 oz 20G/1000 ft row (heavy soils).

Lay-by Application

- Bifenthrin - 3.2 -9.6 fl oz 2EC/A

Foliar Application (for control of the adult stage of wireworms)

- Bifenthrin – 2.1-6.4 fl oz 2EC/A

Alternative Controls

Crop rotation or frequent cultivation of the soil may help to reduce wireworm populations in the soil. Growers avoid planting in fields high in organic matter (5).

Colorado Potato Beetle (CPB)

Damage and Life Cycle

The Colorado potato beetle, *Leptinotarsa decemlineata*, is the most important insect pest in potatoes in the Northeast. Uncontrolled populations can completely devastate a potato field by late July (5). Adults overwinter in the soil and emerge from late April through May, when they invade host crops. Adults mate after they are established on the plants (8). This first generation of adults feeds on the foliage of emerging plants and can do considerable damage when populations are high, although young plants usually can outgrow the damage (5, 8). Females deposit eggs in clusters on the underside of leaves. A single female can produce about 500 eggs in a 3-week period before she dies. The larvae hatch in 4 to 8 days and feed on foliage for about 3 weeks, often stripping plants of leaves and leaving only the main branches. Because eggs are laid in clusters, larvae are distributed in clumps throughout the field (8). Larvae grow through several stages, all of which feed on the foliage (5). When mature, they construct a small spherical cell in the soil at the base of the plants, where they pupate. The second generation of adults emerges in 5 to 10 days, and beetles mate to produce a second generation of larvae. Adult beetles and larvae continue feeding on potato plants, but damage in midsummer is less severe because plants are larger and because beetle egg production is inhibited at temperatures above 80^{o}F. In Delaware, beetles go through 2 generations and a partial third each growing season (8).

Frequency of Occurrence

The Colorado potato beetle is the most economically important insect pest of potatoes in the mid-Atlantic and throughout the Northeast (5). It is an important management issue every year in Delaware. The proximity of a field to overwinter sites is an important factor affecting the severity of early season infestations (8).

Management

Various strategies are used in combination by Delaware growers to manage Colorado potato beetle populations. Crop rotation is critically important, and the growers plant potatoes as far as possible from fields previously planted in potatoes or other solanaceous crops. Scouting and treatment thresholds, as well as careful insecticide selection are also important (6).

When potatoes are planted in fields adjacent to beetle overwintering sites, a preplant or planting application of imidacloprid (Admire) may be used (6). Fields are scouted twice weekly following plant emergence, and the number of colonizing adults is noted. Often adult numbers are not numerous enough to justify insecticide treatment and growers delay spraying until after the first generation of eggs have hatched (8). In Delaware, approximately 70% of the potato acreage is scouted for CPB. Throughout the season thereafter, fields are scouted weekly for CPB to determine the need to spray. At least 10 sites per field are inspected along a V- or W-shaped path. At each site, one stem from each of five adjacent plants are examined, and the number of CPB adults, large larvae and small larvae are counted. As a general guideline, if more than 50 adults or 75 large larvae or 200 small larvae are counted per 50 stems, an insecticide treatment is applied (6).

Pesticide Resistance Management

Do not rely exclusively on the neonicotinoid class of insecticides (Class 4: Actara, imidacloprid (Admire/Provado), Assail, Cruiser, Gaucho, Platinum or Venom) for CPB control. It is important to use all available effective pest management strategies, including crop rotation, pest scouting, treatment thresholds, and alternative (different class) insecticides, such as abamectin, Avaunt plus PBO, cryolite, Entrust, Rimon, SpinTor, Thionex or Vydate.

For rotated fields adjacent to beetle overwintering sites or contiguous to previous year's potato fields, most of the colonizing adults can be killed by treating only a strip of rows along the field edge where the invasion front is expected. Fields should still be monitored for beetles and other insect pests throughout the season.

Preplant or Planting Application

- Imidacloprid (Admire)--0.9-1.3 fl oz 2F/1,000 row ft
- Cruiser--5SF (seed treatment only)
- Gaucho Tops MZ--12 oz ST/100 lb. seed (seed treatment only)
- Platinum--5-8 oz 2SG/A

- Radiant – 6.8 fl oz SC/A
- Venom--6.5-7.5 oz 70SG/A

Postemergence Application

Rotation to nonsolanaceous crops (crops other than potato, tomato, eggplant, and pepper) is extremely important in reducing CPB problems. The further you can plant your fields from last year's solanaceous crop, the more beneficial it will be to reducing CPB problems. Avoid the application of late-season sprays to prevent the buildup of insecticide-resistant beetles.

Beginning at plant emergence, sample fields weekly for CPB to determine the need to spray. Select at least 10 sites per field along a V- or W-shaped path throughout the field. At each site, select one stem from each of five adjacent plants and count and record all adults, large larvae (more than halfgrown), and small larvae (less than half-grown). As a general guideline, if more than 50 adults or 75 large larvae or 200 small larvae are counted per 50 stems, a treatment is recommended. The amount of yield loss as a result of CPB feeding depends on the age of the potato plant. Superior variety (short season) cannot compensate for early season defoliation by overwintered beetles, but during the last 30 days of the season, Superior can withstand up to 50 percent defoliation without yield loss. Several of these insecticides may no longer be effective in certain areas of the state due to CPB resistance. Growers are encouraged to check with their county Extension agents for the most effective controls.

- Actara--1.5-3.0 oz 25WDG/A
- abamectin (Agri-mek)--8-16 fl oz 0.15EC/A
- Assail--1.5-4 oz 30SG/A
- Avaunt--3.5-6.0 30WDG/A (Larvae only). The addition of 0.25 lb ai/A of the synergist piperonyl butoxide (PBO) is necessary when using Avaunt.
- azadirachtin (Azatin, Ecozin, Neemix)--7-16 fl oz EC/A. Apply when pests first appear and are in their early larval stages
- *Bacillus thuringiensis tenebrionis* (Small CPB larvae only--Novodor)—Make first application when eggs begin to hatch and repeat applications at 5- to 7-day intervals if small larvae are present. NOT effective against large larvae and adults. If rainfall occurs within 24 hours posttreatment, reapplication may be necessary. Larval reduction may not be noticeable for 48 to 72 hours after application
- cryolite (Kryocide, Prokil cryolite)--10-12 lb 96WP/A
- Entrust--1.0-2.0 oz 80W/A
- Imidan--1.33 lb 70W/A
- imidacloprid (foliar-Provado)--3.75 fl oz 1.6F/A
- Rimon--9-12 fl oz 0.83 EC/A
- SpinTor--3-6 fl oz 2SC/A
- Thionex--0.66-1.33 qt 3EC/A
- Venom--1-1.5 oz 70SG/A

- Vydate L--1-4 pt 2L/A

DO NOT use foliar applications of neonicotinoid insecticides (Actara, Provado, generic imidacloprid; Leverage or, Venom) in fields treated at planting with neonicotinoids (Admire, generic imidacloprid, Platinum, or Venom).

Flea Beetles (FB)

Damage and Life Cycle

Potato flea beetle (*Epitrix cucumeris*) is common throughout the Northeast and is known to transmit early blight and bacterial ring rot. It feeds on a variety of crops, including eggplant, tomatoes, peppers, and potatoes. Adult beetles overwinter in crop debris or weedy areas near fields and become active in early spring. They feed on a variety of herbaceous plants until potatoes emerge. Eggs are deposited on the soil at the base of plants, about 100 eggs per female. Larvae emerge after about 10 days and burrow into the soil, where they feed on roots, sprouts, and tumors, weakening plants and sometimes killing seedlings. They pupate in the soil. Adult beetles emerge and burrow to the surface. They climb onto plants and chew small holes in the foliage which can facilitate the entry of plant pathogens. Beetles may also spread diseases from plant to plant as they feed. The life cycle takes 4 to 6 weeks to complete. There are two to three generations per year in Delaware. Young plants attacked early in the season suffer the most damage (5).

Frequency of Occurrence

Potato flea beetle is an occasional pest in our area, but it is usually controlled by insecticide applications made to control other insect pests (3).

Management

Chemical control specifically for flea beetles is not needed every year, probably due to inadvertent control of beetles by insecticide applications made for other insect pest species (3). Chemical control may be utilized when the first generation population is high, to reduce the potential for disease transmission and prevent later populations from reaching economic levels.

Chemical Control

- Asana XL-- 5.8-9.6 fl oz 0.66 EC/A
- Assail--1.5-2.5 oz 30SG/A
- Baythroid XL--1.6-2.8 fl oz/A
- Bifenthrin – 2.1-6.4 fl oz 2EC/A
- Imidan--2 lb 50WP/A
- Lambda-cyhalothrin
- Lannate--1.5-3 pt LV/A
- Platinum--5-8 oz 2SG/A
- permethrin--4-8 fl oz 3.2EC/A
- Renounce – 2-3.5 oz 20WP
- Thionex--0.66-1.33 qt 3EC/A

- Venom--6.5-7.5 oz (soil); 1-1.5 oz (foliar) 70SG/A
- Vydate L--2-4 pt 2L/A

Alternative Controls
Control of early spring weeds near potato fields and cultivation are used to reduce overwintering and reservoir populations of flea beetles (5).

Potato Leafhoppers (PLH)

Damage and Life Cycle
Potato leafhopper is an annual serious pest of potatoes that causes significant crop damage, even when populations are low (9, 11). It also attacks beans and a range of other vegetable crops. Adults overwinter in the South and move into the mid-Atlantic area each spring (11). Adults insert eggs singly into stems or leaf veins of susceptible plant species. Eggs hatch in 7 to 10 days, and nymphs develop into adults over a period of 2 to 3 weeks (9). Both adults and nymphs feed by piercing the underside of leaves and sucking plant juices. As they feed, they inject a toxin into plant tissues which is taken up by the plant and inhibits normal development by disrupting the flow of nutrients from photosynthetic tissues to the rest of the plant (9, 11). Early symptoms of leafhopper feeding include a rolling and yellowing of the leaves. Leaves later turn brown and die (9). High levels of leafhoppers in potatoes can cause extensive leaf-yellowing known as "hopper burn," although many varieties show few symptoms of hopper burn and yet can incur significant yield losses (6, 9). Yield losses from potato leaf hoppers can be substantial (9).

Frequency of Occurrence
Potato leafhopper is a serious annual pest of potatoes in Delaware. Even relatively low numbers of leafhoppers can cause a significant yield reduction (9). Because nymphs are susceptible to desiccation, populations tend to be lower during very dry summers (11).

Management
Fields are monitored from early June through early August for the buildup of potato leafhoppers (6). Sweep net samples are used to monitor adult populations and leaves are inspected for the presence of nymphs (11). Growers make a foliar insecticide application when adult counts exceed 1 per sweep or if more than 1 nymph per 10 leaves is found (6). Admire applied at planting and foliar insecticides applied on as an needed basis are the only means of controlling potato leafhoppers.

Chemical Control
Monitor fields for the buildup of leafhoppers from early June until early August. Treatment is suggested if leafhopper counts exceed 1 adult per sweep or 1 nymph per 10 leaves.

- Actara--1.5-3.0 oz 25WDG/A. Control may require 2 Applications at 7- to

10-day intervals)
- Imidacloprid
- Asana XL--2.9-5.8 fl oz 0.66 EC/A
- Assail--1.5-4 oz 30SG/A
- Baythroid XL--1.6-2.8 fl oz/A
- Dimethoate – 0.5-1 pt 4EC/A
- Imidan--2 lb 50WP/A
- Lambda-cyhalothrin
- Lannate--1.5-3 pt LV/A
- Platinum--5-8 oz 2SG/A
- permethrin--4-8 fl oz 3.2EC/A
- Renounce – 1-2 oz 20WP
- Thionex--0.66-1.33 qt 3EC/A
- Venom--6.5-7.5 oz (soil); 1-1.5 oz (foliar) 70SG/A
- Vydate L--2-4 pt 2L/A

Alternative Controls
No alternative controls are used in the management of this pest.

European Corn Borer (ECB)
(Ostinia nubilalis)

Damage and Life Cycle
The European corn borer feeds on a wide variety of crops, including potatoes. It overwinters as a mature larva in its burrow in the sweet corn stalk or in the stem of a different host plant (5). Larvae pupate in late April or early May, and adults emerge in late May or early June (11). Female moths lay their eggs on the underside of leaves or on stems (9). A single female can produce as many as 500 eggs during her lifetime (5). Eggs hatch in 4 to 7 days (depending on temperature) and young larvae feed on plant foliage for 7 to 12 days before boring into the stems (11). Stem damage weakens the plant by interfering with translocation of water and nutrients. This insect produces 2 to 3 generations a year in the mid-Atlantic area (11). The stem boring activities of the first larval generation cause the most damage to potatoes in Maryland (9). Insecticide sprays made to control other potato pests in July and August, and the availability of preferred hosts, prevent later generations from causing extensive damage to potatoes (5).

Frequency of Occurrence
European corn borer is a major pest of field corn and sweet corn throughout the United States and Canada, and feeds on a large range of other host plants, including potato (5). The timing and extent of damage to the potato crop can fluctuate from year to year and from region to region (12). Moth populations can fluctuate considerably annually as well (13).

Management

A degree-day system has been established for predicting the life stages of the first generation. Scouting begins at 500 degree days and continues through 700 degree days or when egg masses are less numerous. Scouts count egg masses on the undersides of leaves on the bottom half of the plant. More than 1 egg mass per 25 leaves may indicate a problem. Black light traps are also used to monitor populations of adults. Catches exceeding 25 adults per night indicate that adult may produce enough eggs to justify an insecticide treatment (9).

Chemical Controls

Proper timing of ECB sprays is critical. Apply first spray when 10% of the stems have entry holes in fresh market varieties or 25% in processing varieties. Make two to three applications on a 5- to 10-day schedule.

- Avaunt--3.5-6.0 oz 30WDG/A
- Baythroid XL--1.6-2.8 fl oz /A
- Furadan--1-2 pt 4F/A
- Lambda-cyhalothrin – 2.56 – 3.84 fl oz 3/A
- Monitor--1.5-2 pt 4EC/A
- Penncap-M--2-4 pt 2FM/A
- Radiant – 6-8 fl oz SC/A
- Renounce – 2-3.5 oz 20WP
- RIMON – 9-12 FL OZ 0.83
- SpinTor--3-6 fl oz 2SC/A
- Asana XL--5.8-9.6 fl oz 0.66EC/A
- permethrin--4-8 fl oz 3.2EC/A

If a pyrethroid (Asana XL, Baythroid XL, permethrin) is used for ECB control, make first application when 8 to 10 ECB moths are being trapped in local pheromone or blacklight traps. Apply two to three additional applications at 5- to 7-day intervals, based on moth activity.

Alternative Controls

Resistant Varieties: none available that are commercially used in Delaware.

Natural Enemies

There are several natural enemies of European corn borer, but these rarely provide sufficient control. Also, enemy populations are often depleted by the use of insecticides to control European corn borer and other pest species in potatoes (5).

Potato Aphid (POA), Green Peach Aphid (GPA), and Melon Aphid

Damage and Life Cycle

Several species of aphids feed on potatoes, and all inflict similar types of injury to plants. Aphids overwinter as eggs on a variety of host plants. Green peach aphids overwinter in the south and migrate into our area, or overwinter in greenhouses and are introduced with bedding plants. Potato aphids overwinter as eggs on wild and cultivated rose plants, and certain weed species including

lambsquarters, yellow mustard, and redroot pigweed (5) Aphid nymphs hatch in spring and feed until they mature. Adults of this first generation reproduce sexually, bearing live young which mature into winged adults and migrate onto crops. This generation feeds on plants and rapidly reproduces asexually, with a generation time of 5 to 7 days. Many overlapping generations occur, and populations can increase rapidly. Most species of aphids produce a winged, sexually reproductive generation near the end of the growing season (9). Green peach aphids and potato aphids are the most important of several aphid species that attack potatoes in Delaware. The melon aphid can also cause significant damage. All three aphid species attack plants throughout the growing season, but damage is usually worst in May and June, and again in the fall. Aphid infestations commonly begin in small scattered areas over the field. Aphids are found primarily on the underside of the leaves, where they suck sap from the plant. Green peach aphids favor mature lower leaves while potato aphids are found primarily on terminal leaves and young stems (8). Infested leaves curl downward and may turn brown and die (9). When infestations are heavy, aphid damage can reduce plant vigor, size and yield, and may kill the plants. (8).

Frequency of Occurrence

The green peach aphid is a major pest of potatoes everywhere they are grown (10). The green peach aphid and the potato aphid are the most common species of aphids found on potatoes grown for the fresh market in the Northeast (5). The melon aphid is also found on potatoes in our area (6). Aphids are present every year, but typically affect potato yields only when their populations reach very high levels.

Management

Fields are scouted for the presence of aphids 2 or 3 times during the growing season, in May and early June for the potato aphid, and in late June for the green peach aphid (8). Scouting is done by looking for wilting and curled leaves throughout the field. When aphids are detected, more intense sampling is done to determine infestation levels and natural enemy activity. An insecticide is applied to control potato aphids and green peach aphids if combined counts exceed 2 per leaf prior to bloom, 4 per leaf during blooming, or 10 per leaf within 2 weeks of vine killing. For melon aphids, the thresholds are lower: 1 per leaf prior to bloom, 2 per leaf during blooming, or 5 per leaf within 2 weeks of vine killing (6).

Chemical Controls

Potato Aphid (POA) and Green Peach Aphid (GPA)

Insecticide treatments are recommended when aphid counts exceed 2 per leaf prior to bloom, 4 aphids per leaf during bloom, and 10 aphids per leaf within 2 weeks of vine kill.

- Actara--3.0 oz 25WDG/A
- Assail--1.5-4.0 oz 30SG/A
- Beleaf – 50 SG

- dimethoate (POA only)--0.5-1 pt 4EC/A
- Fulfill--2.75 oz 50WDG/A
- Lannate--1.5-3 pt LV/A
- Monitor--1.5-2 pt 4EC/A
- Platinum--5-8 oz 2SG/A
- imidacloprid (foliar)
- Thionex--0.67-1.33 qt 3EC/A
- Venom--6.5-7.5 (soil); 1-1.5 oz(foliar) 70SG/A
- Vydate L--2-4 pt 2L/A

Melon Aphid
Insecticide treatments are recommended when aphid counts exceed 1 per leaf prior to bloom, 2 aphids per leaf during bloom, and 5 aphids per leaf within 2 weeks of vine kill.

- Actara--3.0 oz 25WDG/A
- Assail--1.5-4.0 oz 30SG/A
- Beleaf – 50 SG
- Fulfill--2.75 oz 50WDG/A
- Lannate--1.5-3 pt LV/A
- Monitor--1.5-2 pt 4EC/A
- Platinum--5-8 oz 2SG/A
- imidacloprid (foliar)
- Thionex--0.67-1.33 qt 3EC/A
- Venom--6.5-7.5 (soil); 1-1.5 oz(foliar) 70SG/A
- Vydate L--2-4 pt 2L/A

Natural Enemies
Aphids may be controlled naturally by parasitic wasps and a variety of predators, including lady beetles and their larvae, lacewing larvae, and syrphid fly larvae. When making a treatment decision, natural enemy populations are considered (8). During periods of high humidity, fungal diseases may also help reduce aphid populations.

Potato Tuberworm

Treat when foliage injury is first noted. Four to five applications at 7- to 14-day intervals may be needed. Tuberworms are primarily a problem on the fall crop. Because moths are actively flying at dusk, sprays are most effective when applied early evening.

- Asana XL--2.9-5.8 fl oz 0.66EC/A
- Baythroid XL--1.6-2.8 fl oz /A
- Lannate--1.5-3 pt LV/A
- Monitor--1.5-2.0 pt 4EC/A
- permethrin--4-8 fl oz 3.2EC/A
- Renounce 2-3.5 oz 20WP

Cutworms

Damage and Life Cycle

A number of cutworm species attack crop plants. They are active mainly at night, and hide in soil or debris during the day (5). Variegated cutworms feed primarily on potato foliage on lower stems. Black cutworms feed mainly on stems at or below the soil surface, but will also feed on foliage (6). First generation larvae may attack young seedlings, often snipping stems near the soil surface (5, 6). Most cutworm species overwinter as late instar larvae (5). Adults emerge in early to mid summer, and are present in our area during July and August (6). Some species, possibly the black cutworm, overwinter farther south and adults migrate into our area (15). Females deposit eggs on debris, grasses, or weed leaves and stems (5). Weedy or minimum-tillage fields are favored egg-laying sites (6). Eggs hatch in 5 to 14 days, depending on species (5, 15). Larvae develop through several instars, feeding on plants for weeks before pupating in the soil. Cutworms may also attack exposed tubers through cracks in the soil, leaving shallow feeding holes (5, 6). One to three generations occur each year, depending upon species (5).

Frequency of Occurrence

Cutworms are a minor pest of potatoes in Delaware (14). There is considerable variation in this pest regionally. Moth populations can fluctuate considerably from year to year as well (13). In dry years, low lying areas of the field are more subject to attack than other areas (6).

Management

For cutworms that feed below the ground, neither foliar nor systemic insecticides are effective. In fields where high cutworm populations are expected, a broadcast incorporated insecticide may be applied and worked into the soil immediately prior to planting. Whether or not this strategy is used, fields are scouted for cutworm damage after plant emergence. Protective sprays are applied if more than 6 variegated cutworms are found per plant, or if more than 10% feeding damage is incurred. Also, if cutworms are actively cutting plants, a contact insecticide is applied at the base of plants at night (6).

Chemical Controls

Cutworms are present during July and August. They are especially troublesome to tubers where soil cracking occurs. Variegated cutworms feed on lower leaves and petioles, and protective sprays should be applied if numbers exceed six worms per plant or foliar loss is more than 10 percent. Black cutworms are largely underground feeders, but will occasionally feed on leaves. No materials are effective if larvae do not feed aboveground (foliar and systemic insecticides are ineffective). Several spray applications may be required for control. Insecticides should be applied at the base of plants at night, with a high volume of water, to achieve the best possible control (5).

- Asana XL--5.8-9.6 fl oz 0.66EC/A

- Baythroid XL--0.8-1.6 fl oz /A
- Lambda-cyhalothrin – 1.92 – 3.2 FL OZ 3/a
- Lannate--1.5 pt LV/A (variegated cutworm only)
- permethrin--4-8 fl oz 3.2EC/A
- Renounce 1-2 oz 20WP
- Sevin--2.5 lb 80S/A
- Sevin Bait--40 lb 5% bait/A

Alternative Controls

A number of predators and parasites help to reduce cutworm populations, including birds, ground beetles, parasitic wasps and flies, and diseases (5, 10). Plowing in the fall may be used to destroy some life stages (5). Good weed control is important, since moths often favor weedy sites to deposit eggs (6).

INSECTICIDE TABLE (4)

Insecticide	**Use Category**	**Hours to Reentry**	**Days to Harvest**
Actara	G	12	14
abamectin(Agri-mek)	R	12	14
Asana XL	R	12	7
Assail	G	12	7
Avaunt	G	12	7
azadirachtin	G	12	0
Bacillus thuringiensis	G	4	0
Baythroid XL	R	12	0
Beleaf	G	12	7
Bifenthrin	R	12	21
Cruiser	G	12	At plant
cryolite	G	12	0
dimethoate	G	48	7
Entrust	G	4	7
Fulfill	G	12	14
Furadan 4F	R	48	14
Gaucho	G	12	At plant
imidacloprid (Admire; Provado)	G	12	12/7
Imidan	G	24	7
Lambda-cyhalothrin	R	24	7
Lannate	R	48	6
Mocap	R	48	At plant
Monitor	R	48	14
Penncap-M	R	5 days	5
Platinum	G	12	30
permethrin	R	12	14
Radiant	G	4	7
Regent	R	0	90

Renounce	R	12	0
Rimon	R	12	14
Sevin/Sevin Bait	G	12	7/12
SpinTor	G	4	7
Thimet	R	48	90
Thionex	R	24	1
Venom	G	12	pre-plant, pre-emerge cracking- soil 7-foliar
Vydate L	R	48	7

Use Category = G = general, R = restricted
Hours to Reentry = Chemicals with multiple designations are based on product and/or formulation differences.

DISEASE CONTROL (2, 4)

Air Pollution

Symptoms appear as tiny spots of brown tissue on the upper surface of leaves and a bronzing of the lower surfaces. Some varieties such as Kanona, Norland, Red Lasoda, Red Norland, and Snowden are particularly sensitive.

Early Blight

Damage and Life Cycle

Early blight affects both the foliage and the tubers of potato plants, particularly those that are older or stressed. It is caused by the fungus *Alternaria solani*, which overwinters in the soil and on refuse of potatoes and related plants in the field. Spores come in contact with leaf tissue and germinate under moist conditions. The fungus penetrates leaf tissues long before symptoms become apparent. Foliar symptoms most often appear soon after flowering, and are usually first observed on older, lower leaves. Brown leaf lesions with concentric rings surrounded by a yellow margin characterized the early foliar phase. Lesions become angular where fungal growth is limited by veins. As the disease spreads, lesions appear on younger, higher leaves, and dark lesions may also appear on the stems. Tuber infections may occur at harvest when soil dwelling spores come in contact with tubers. The fungus requires moisture on tuber surfaces to initiate infection, and can enter mature tubers through wounds or lenticels (which are open when the tuber surface is wet). Immature tubers and those harvested from coarse sandy soils under wet conditions are more susceptible to infection. Circular or irregular dark lesions, often with a purple border, are visible on the skin. The tissue below is typically brown, dry and corky, but becomes yellowish and water soaked in the later stages of infection. Yield loss ranges from 1 to 5%.

Frequency of Occurrence

Early blight occurs worldwide where potatoes are grown. Spread of the disease is favored by alternating wet and dry conditions. In severe foliar infections, tuber

yields may be significantly reduced. Early blight is not a large concern for most growers, except where susceptible cultivars, such as Belrus and Conestoga, are grown.

Management
This disease is managed with resistant cultivars and a combination of chemical and cultural controls.

Chemical Controls
Begin sprays in mid-June and continue every 7 to 10 days or apply fungicides according to a disease forecasting system. If late blight is a threat, then begin sprays when plants are 8 inches tall. Gem, Headline and azoxystrobin (Quadris, Amistar, Quadris Opti) are particularly effective on early blight susceptible Varieties.
Alternate:
one of the following fungicide programs

- chlorothalonil--1-1.5 pt 6F/A
- Endura--2.5-4.5 oz 70W/A
- mancozeb--1.5-2 lb 75DF/A (DO NOT apply more than a total of 15 pounds of mancozeb or Polyram per acre per crop)
- Polyram--2 lb 80DF/A or OLF (DO NOT apply more than a total of 15 pounds of mancozeb or Polyram per acre per crop)
- Super Tin--6 fl oz 4L/A *plus* mancozeb--2 lb 75DF/A

With:

- azoxystrobin (Quadris 6.2-15.4 fl oz 2.08F/A or Amistar at 2-4 oz 80WDG/A)
- Gem--6-8 oz 25WDG/A
- Headline--6-9 fl oz 2.1F/A
- Quadris Opti--1.6 pt/A
- Reason--5.5- 8.2 fl oz 500SC/A

Alternative Controls
Good cultural practices often are enough to prevent economic losses from early blight. Any management practices that reduce plant stress, including fertility management, also reduce the occurrence of early blight. Tubers are not harvested until about 2 weeks after vine kill, when they are fully mature. Harvesting under wet conditions is avoided, and care is taken during harvest to avoid tuber injury. Forced air is used to dry tubers placed in storage, and rapid wound healing is promoted.

Late Blight

Damage and Life Cycle
Late blight is caused by the fungal pathogen *Phytophthora infestans*, which overwinters in infected tubers left in the field in cull piles. Shoots from these tubers are a source of inoculum early in the growing season. Temperatures below 78˚F combined with high humidity or abundant water from irrigation or

rainfall provide conditions for disease development. Spores spread to new plants, causing small water-soaked lesions at leaf tips or margins. Lesions expand and turn dark brown or purplish-black, with green, water-soaked margins. If conditions remain favorable, spore-producing white mycelium appear at the margins of the lesions, particularly on the underside of the leaves. The stems of infected plants develop dark lesions and may wilt and die. The disease tends to spread across the field in a tear-drop pattern originating from the first infected plant. Tubers become infected when they come in contact with spores deposited on the soil from infected foliage. Even when foliar infections are minimal, significant damage to tubers can result. Irregular brownish-purple lesions of variable size with black margins appear on the tuber surface. A brown granular rot which lacks a distinct margin penetrates a short distance (< 2 cm) into the tissue. Under improper storage conditions with abundant moisture, infection may spread to other tubers, and secondary infections of bacterial soft rot may follow.

Frequency of Occurrence

Late blight is probably one of the most important and damaging diseases of potatoes worldwide. It does not occur every year in the are, and when it does, it is often associated with infected seed pieces. Infections of late blight can occur as early as June.

Management

This disease is managed with preventive fungicide sprays and a combination of cultural and mechanical management strategies. Late-blight forecasting models are used in the East to determine the timing of protective fungicide applications.

Resistance Issues

New strains of *Phytophthora infestans* are present in the mid-Atlantic region. These strains are aggressive on potatoes and are resistant to Ridomil Gold.

Chemical Control

Begin fungicide applications when plants are 6 inches tall and repeat every 7 days or apply fungicides according to a disease forecasting system such as BLITECAST or WISDOM. The following protective fungicides should be applied early in the season prior to the occurrence of any disease in the region:

- chlorothalonil--1-1.5 pt 6F/A
- mancozeb--1.5-2 lb 75DF/A (DO NOT apply more than a total of 15 pounds per acre per crop)
- Polyram--2 lb 80DF/A. (DO NOT apply more than a total of 15 pounds per acre per crop).

The following fungicides can be used when the threat of the disease is high or present in the area and protectant fungicides have been used prior to disease occurrence:

- Curzate--3.33 oz 60DF/A plus a protectant fungicide (ie, chlorothalonil or mancozeb)

- Forum--4.0-6.0 fl oz 4.18SC/A plus a protectant fungicide
- Gavel--1.5-2 lb 75DF/A
- Headline--6-9 oz 2.1F/A
- Omega--5.5 fl oz. 500F/A
- Previcur Flex--1.2 pt 6F/A plus a protectant fungicide (ie, chlorothalonil or mancozeb)
- Ranman--1.4-2.75 fl oz 400SC/A
- Tanos--8 oz 50W/A *plus* a protectant fungicide (ie, chlorothalonil or mancozeb)

When a field contains new late blight infections and harvest is near, vines should be killed immediately to help prevent tuber infection.

Alternative Controls

Cultural control practices include planting resistant cultivars where possible, crop rotation, the use of certified seed, and removal of cull piles and debris from the previous year's crop. Volunteer plants, a potential source of inoculum are removed or killed with herbicide. Tuber infection is minimized by hilling to keep tubers covered at all times. When a field contains new late blight infections and harvest is near, vines are killed immediately and tubers are not harvested until 2 weeks later, allowing time for spores on the foliage to die. Harvesting under wet field conditions is avoided. To prevent tuber infection from spreading in storage, good ventilation and the lowest possible temperatures are used.

Rhizoctonia stem canker and black scurf

Damage and Life Cycle

Rhizoctonia stem canker is caused by the fungus *Rhizoctonia solani*. This pathogen attacks a variety of crops and weeds; however, the specific strain that attacks potatoes does not infect other crops. Stem canker affects both the foliage and the tubers of potato plants. This disease attacks underground stems, shoots and stolons. Wet, cold weather and poorly drained soils promote infection of plants, especially during shoot preemergence. Temperatures around 64F or below are optimum conditions for disease development. The pathogen enters the stems and sprouts through wounds; later in the season, the pathogen infects roots and stolons. Under cool and wet environmental conditions, sclerotia will be formed on the surface of the tubers. The dark sclerotia that forms on the tuber surface is known as "black scurf." The sclerotia may make the tubers unmarketable. The most common symptoms are reddishbrown lesions on underground parts of the stems and stolons, whitish stems, formation of aerial tubers at the base of the stems and damage to the vascular system. When the vascular system is damaged, this results in foliar symptoms, including wilting, stunting, curling, and yellowing. This disease may cause yield reduction.

Frequency of Occurrence

Occurrence depends on the weather; cold and wet soils promote the spread of the disease. Usually this disease does not result in high yield loss, unless the environmental conditions are cool and wet.

Management
This disease is managed mainly with cultural practices.

Chemical Controls
Apply one of the following as an in-furrow spray at planting:

- azoxystrobin (Quadris at 0.4-0.6 fl oz 2.08F/1000 ft of row
- Moncut--0.71-1.1 lb 70DF/A
- Blocker – 5.2-10 fl oz eF/1,000 ft row

Alternative Controls
Several steps are taken to reduce the incidence of stem canker. Growers avoid planting when the soil is cold (below 45F) or wet. The use of only disease-free seed reduces the risk of developing the disease. Another effective control mechanism is to use cultural practices that promote fast sprout emergence. Crop rotations are done with grasses and cereals; however, sugar beet, alfalfa, or clover are avoided. The use of shallow seedpiece covering accelerates the emergence of shoots in the spring .

Verticillium Wilt

Damage and Life Cycle
Verticillium wilt is caused by either of two fungal organisms, *Verticillium albo-atrum* or *Verticillium dahliae*. The fungi commonly inhabit the soil and may also be found on old infected tubers. Inoculum can be carried in infected soil transported by equipment, spread in irrigation water, on air currents, or by root contact between adjacent plants. This disease is characterized by wilting of plants during the growing season. Young infected plants are stunted, and may wilt and die. Older plants turn yellow and die due to early senescence. The rate of senescence depends upon soil moisture level; death is more rapid in damp soils. Leaf yellowing and wilting starts at the base of the plant and moves upward. Necrosis and curling of leaves may also occur. Tubers from surviving infected plants often have a pale brown discoloration of the vascular ring. Cavities can form in severely affected tubers. This disease is particularly severe when soil populations of lesion nematodes (*Pratylenchus penetrans*) are high. Yield loss ranges from 5 to 20%.

Frequency of Occurrence
Verticillium wilt is one of the most damaging diseases of fresh market potatoes in the area. The disease is widespread, occurring wherever potatoes are grown. This disease is not yet a major problem in processing potatoes, perhaps because this is a relatively new crop in our area, and Verticillium populations in the soils have not reached damaging levels. The pathogen was detected in a commercial field of processing potatoes for the first time in 1998.

Management
This disease is managed mainly by crop rotation and the use of resistant varieties where possible.

Chemical Controls
Select fields with a low incidence of wilt. Use resistant varieties where possible. Do not use tomato, eggplant, or pepper in rotation with potato may. The use of sudangrass in rotation with potato may reduce nematode levels. The use of Mocap (see "Nematode Control" section) will reduce lesion nematode levels in the soil, resulting in less Verticillium wilt. Apply one of the following through center pivot irrigation in the fall to fallow fields for suppression of Verticillium and lesion nematode:

- K-Pam HL--30-60 gal/A
- metam-sodium (Vapam HL)--37.5-70 gal/A

Alternative Controls
Resistant cultivars are used wherever possible. Crop rotation and other agronomic practices that control nematodes also reduce Verticillium wilt. Crop rotation is the most important cultural practice, since it reduces inoculum levels of the soil-borne pathogen and is widespread. Rotations to certain unrelated non-host crops, especially sudangrass and other grasses, cereals, and legumes, are most effective. There is an increased interest in the use of these rotations as an alternative control strategy. Rotations to peppers, tomato, or eggplant are avoided, since they are alternate hosts for lesion nematode and are especially susceptible to Verticillium wilt.

White Mold

Damage and Life Cycle
White mold, a cool temperature disease, is caused by the fungal pathogen *Sclerotinia sclerotiorum,* and to a lesser extent by *S. mino* and *S. intermedia*. It affects crops as diverse as beans, carrots, alfalfa, and lettuce. The fungus overwinters in the soil as sclerotia, an irregularly shaped, hard, black lifestage. In the presence of adequate moisture at temperatures above 60oF, sclerotia germinate spore producing structures called apothecia on the surface of the soil. Spores released infect plants locally, or may travel great distances on the wind. If free moisture is available for 48 hours, spores will infect plant tissue. White, water-soaked lesions appear on the stems and leaves, and a white mold develops. In advanced infections, stems may be girdled, killing the plants. Tubers may be infected if they are near the soil surface. Tuber flesh becomes blackened and spongy. A soft, white rot forms inside the tuber, which in advanced stages may develop mycelium-filled cavities. This disease does not result in significant yield loss in potatoes.

Frequency of Occurrence
This disease is uncommon on potatoes in the area.

Management
This disease is managed with a combination of cultural controls and fungicide sprays.

Chemical Controls
Apply the following immediately prior to row closing and repeat 28 days later:

- Endura--5.5-10 oz 70WG/A
- Omega--5.5-8 fl oz 500F/A
- Rovral--2 pt 4F/A
- thiophanate-methyl--1.0–1.5 lb 70WP/A

Alternative Controls
Proper fertilization and careful water management are important for the control of white mold. Growers avoid application of excessive nitrogen and time irrigation so that the leaves are not wet for 48 hours at a time.

Common Scab

Damage and Life Cycle
Common scab is caused by a bacterial pathogen called *Streptomyces scabies,* which overwinters in infected seed pieces and in contaminated soils. This pathogen attacks carrots, beets, turnips, parsnips and radishes, as well as potatoes. Soil pH between 5.5 and 7.5 is favorable for bacterial growth, and dry soil conditions during tuber growth promote disease development. This disease has few obvious foliar symptoms but affects tubers with 2 types of symptoms, depending on the variety. Some cultivars develop shallow, cork-like lesions that coalesce to form pits or raised scabs. Other cultivars develop sunken, circular brown lesions. Although there is typically no yield loss (approximately less than 1%) from this disease, these symptoms may make the tubers unmarketable. Processors can usually accept tubers with raised scabs, but tubers with deep scabs are not suitable for processing.

Frequency of Occurrence
This disease is not a common problem throughout the area.

Control Measures
Chemical control is not recommended for this disease. Growers are advised to use resistant varieties and rotate with green cover crops. Growers should use only disease-free seed and plant into clean soil. Growers should be careful to provide adequate moisture to the field during tuber development. Soil pH should be adjusted downward, where necessary, to inhibit bacterial populations.

Bacterial Soft Rot

Damage and Life Cycle
Bacterial soft rot can affect tubers in storage or in the soil prior to harvest. The disease is caused by the bacterium *Erwinia carotovora,* pv. *carotovora*. The

pathogen enters the tubers through enlarged lenticels, or through cuts or other areas of previous injury, including damage caused by other diseases. The pathogen can also be passed via stolons from an infected plant to its offspring. Symptoms develop under moist, warm storage conditions or soil temperatures above 70oF. Lenticels develop sunken brown watersoaked lesions. Infected tissues in the tuber are wet and creamy to tan with dark brown margins. As rot progresses, the infected tissue gives off a foul odor. If favorable conditions for disease development persist, all the internal tissue of a tuber may be destroyed. Yield loss ranges from 5 to 30%, depending on the weather.

Frequency of Occurrence

Occurrence depends on weather prior to harvest. Hot, wet conditions are favorable. Soft rot often follows tuber diseases, especially pink rot and insect damage.

Management

Wound prevention and packing dry tubers are good management practices. A chlorine wash maintained at 25 ppm is beneficial in controlling soft rot. Care is taken during handling, so as not to damage tubers and increase the risk of infection. Tubers in storage may be protected by a 25 ppm chlorine wash.

Chemical Controls

Prevent wounding and make certain tubers are dry before packing. A chlorine wash maintained at 25 ppm is beneficial in controlling soft rot.

Alternative Controls

Several steps are taken by growers and handlers to reduce the incidence of soft rot. Growers avoid excessive moisture prior to harvest, to lower the rate of lenticel infection. Mature tubers are harvested when soil temperatures are below 68oF, and care is taken not to damage tubers during harvest and subsequent handling. During and following harvest, tubers are protected from excessive sunlight and dessication. After harvest, tubers are cooled to 50oF and stored at low temperatures in a dry, well-ventilated area. Tubers are not washed before storage. If they are washed prior to marketing, clean, chlorine-treated water is used, and tubers are dried completely before placement into well-ventilated containers.

Leak (*Pythium*) and Pink Rot (*Phytophthora*)

Damage and Life Cycle

Leak is caused by the fungal pathogen *Pythium spp.*, which typically enters the plant through mechanical injury, although extremely wet conditions can also promote infection. Infection typically occurs at harvesting or grading, though cut seed pieces can also be affected during planting, especially as soil temperatures increase. Tubers are the only part of the plant affected by infection, and symptoms usually appear after tubers are placed in storage. Discolored, water-soaked spots appear at the site of injury. Infected tubers are swollen, and the

skin is moist. Internal rotted tissue is wet and spongy, and appears dark brown to black when exposed to the air, with a dark line of demarcation between healthy and affected tissue. Within a few days, infected tubers may rot completely. The most serious yield losses occur when immature tubers are harvested during hot, dry weather. Poor ventilation and hot weather also promote the disease. Yield loss ranges from rare to a maximum of 10%.

Frequency of Occurrence
When the weather is hot and dry during harvest, leak occurs infrequently. Leak causes an approximately 10-15% yield loss. This yield loss usually occurs in regions that harvest during hot weather. Harvesting during this time causes the greatest risk of infection.

Management
Leak is managed primarily with fungicides.

Alternative Controls
Growers avoid harvesting too early, to allow tuber skins to mature. Also, harvesting is delayed in exceptionally warm weather or if the soil is wet. Care is taken during harvesting to avoid mechanical injury to tubers. After harvest, tubers are cooled and dried and placed in a well-ventilated storage area. If rotting of stored tubers begins, air flow is increased, and the storage temperature is reduced to 40-45oF.

Damage and Life Cycle
Pink rot is caused by the fungal pathogen *Phytophthora erythroseptica*. The fungus is soil-borne and can survive for long periods outside of a plant host. Wet weather and warm temperatures promote infection of plants. The pathogen can infect roots and stolons, but tuber decay is the most damaging stage of the disease. Foliar symptoms include wilting and necrosis, generally occurring late in the growing season. Lesions form on infected roots, stolons and stems, and dieback occurs in severe infections. Tubers may become infected through diseased stolons, or infection may enter the tuber through eyes or lenticels. Affected tuber tissue is spongy but not discolored. Infected tubers ooze spore-containing liquid which can spread infection to other tubers in storage. Yield loss varies from 2 to 60%, depending on the weather.

Frequency of Occurrence
Pink rot usually occurs during wet weather close to harvest, on land that has been planted with potatoes without long rotations. It is also more prevalent in low areas and areas that are compacted (spray rows, etc.). Usually yield loss due to pink rot ranges from 5 to 10%; however, on the Eastern shore, yield loss can reach 30% on very susceptible varieties.

Management

This disease is managed with a combination of chemical, cultural, and physical controls.

Alternative Controls

The most important control measure for this disease is growing potatoes on soils with adequate drainage so that soil water does not accumulate around the base of the plants. To avoid rotting of stored tubers, good air flow and low storage temperatures are used. At temperatures below 40oF, the fungus is dormant.

Chemical Controls

Leak is a disease that usually enters the tubers through bruises occurring in conjunction with the harvesting of immature tubers during hot weather. Pink rot generally occurs in poorly drained areas. Be sure to rotate out of potatoes for at least 2 years. Apply one of the following fungicides with as much gallonage as possible. Make three applications of one of the following fungicides. The first application should be made at nickel size tubers. The second and third applications should occur 14 and 28 days later. Be sure to get some coverage of the soil surrounding plants for root uptake to occur.

- mefenoxam/chlorothalonil (Ridomil Gold Bravo, Fluoronil)--2 lb 76WP/A
- Ridomil Gold/Copper--2 lb 70WP/A
- Ridomil Gold MZ--2.5 lb 68WP/A

An alternative application technique is to apply one of the following in a 6- to 8-inch band directly over the seed-piece prior to row closure.

- Platinum Ridomil Gold--2.2 fl oz 1.6E/1000 feet of row
- Ridomil Gold--0.42 fl oz 4E/1,000 feet of row
- Ultra Flourish--0.84 fl oz 2E/1,000 feet of row.
- Ranman – 0.42 fl oz/1,000 ft row

Vine Killing

Potato vines are frequently killed prior to harvest. Vine desiccation facilitates harvest by reducing excessive potato foliage or weed growth. In early harvests, vine desiccation can hasten or improve skin set on relatively immature potatoes, thus reducing tuber damage during grading, packing and shipping. Proper skin set of the potato improves shelf life, assists with retention of potato quality during transport, and improves eye appeal. Also, market demand for smaller (B-size) potatoes of some varieties may be greater for mid-size tubers than for large tubers and continued tuber sizing stops following vine desiccation. Decisions as to when to apply vine desiccants must be based on intended market, demand for a given size, and the need for high-quality, non-skinned tubers.

- Diquat--0.25 to 0.5 lb/A. Apply 1 to 2 pts/A of Reglone for preharvest vine desiccation in a minimum of 20 gallons of water per acre by ground application. Add a non-ionic surfactant (NIS) containing 75% or greater surface active agent at 0.25 to .05% v/v (1 to 2 qts/100 gals) of the finished spray volume. Rainfall 30 minutes following application will not affect the activity of Reglone. Do not apply to drought stressed potatoes. A

second application may be made if necessary in dense vine growth. Do not exceed a total of 4 pts/A of Reglone. If two applications are made, allow at least 5 days between applications.

- Glufosinate-ammonium—0.38lb/A. Apply 3 pt/A Rely at the beginning of natural vine senescence in a single application. Potatoes with heavy or dense vines may require an application of another desiccant (diquat) to complete vine desiccation. Thorough coverage of vines is essential for satisfactory results. Do not harvest potatoes within 9 days of Rely application nor apply to potatoes grown for seed. Do not plant treated areas to wheat, barley, buckwheat, millet, oats, rye, sorghum or triticale until 30 or more days after Rely application.

Sprout Inhibitors

Apply the following directly to tubers:

- Chloropropham—1% Solution. Apply Sprout Nip 3EC as a 1% solution (1 gallon of Sprout Nip per 35 gallons of water) on the drying table after potatoes have been washed. The spray nozzle should be set to spray evenly across the rollers moving the potatoes. The spray solution should be applied at the rate of 1 quart of the 1% solution per 2000 pounds (20 cwt bags) of potatoes. Rollers will distribute the spray solution and assure complete coverage of each potato.
- Maleic hydrazide (MH-30 SG) Apply to crop 2-3 weeks after full bloom or when harvestable tubers are at least 1.5” in diameter. Do not apply when the temperature is expected to exceed 80°F (26.6°C) that day.

Storage

Vines of potatoes going into storage should be completely dead at least 14 to 21 days before harvest. Healing of cuts and bruises is most rapid at a tuber temperature of 50˚ to 60˚Fand a relative humidity of 90 to 95%, but no free water. This temperature should be provided for 2 to 3 weeks at the beginning of the storage period. After this, the temperature should be lowered to 40˚F for table stock or seed potatoes. Where a "rot potential" such as field frost, late blight, or soft rot is present, the curing period should be eliminated, and the temperatures lowered to 45˚F (7.22˚C) as soon as possible with increased air flow. Monitor the storage daily and if the rot continues the crop should be sold.

FUNGICIDE TABLE (4)

Fungicide (FRAC group)	Use Category	Hours to Reentry	Days to Harvest
Blocker (Group 14)	G	12	at plant
chlorothalonil (Group M5)	G	12	0
Curzate (Group 27)	G	12	14
Endura (Group 7)	G	12	30
Flouronil (Groups 4 + M5)	G	48	14
Forum (Group 40)	G	12	4

Gavel (Groups 22 + M3)	G	48	3
Gem (Group 11)	G	12	7
Headline (Group 11)	G	12	3
Iprodione (Group 2)	G	12	14
mancozeb (Group M3)	G	12, 24	3
Moncut (Group 7)	G	12	at plant
Omega (Group 29)	G	48	14
Polyram (Group M3)	G	24	3
Previcur Flex (Group 28)	G	12	14
Quadris (Group 11) G 4 14			
Quadris Opti (Groups 11 + M5)	G	12	14
Ranman (Group 21)	G	12	7
Reason (Group 11)	G	12	14
Ridomil Gold Bravo (Groups 4 + M5)	G	48	7
Ridomil Gold Copper (Group 4 + M1)	G	48	7
Ridomil Gold MZ (Groups 4 + M3)	G	24	3
Rovral (Group 2)	G	12	14
Super Tin (Group 30)	G	24, 48	21
Tanos (Groups 11 + 27)	G	12	14
Thiophanate-methyl (Group 1)	G	12	14
Ultra Flourish (Group 4)	G	48	0

Use Category = G = general, R = restricted
Hours to Reentry = Chemicals with multiple designations are based on product and/or formulation differences.

Nematode Control (4)

- Mocap--20 lb 15G/A or OLF. Apply in a 12-inch band on the row at planting (avoid contact with seed piece).

Subject matter contacts at the University of Delaware, College of Agriculture and Natural Resources:

- Joanne Whalen
- Bob Mulrooney
- Mark VanGessel
- Tracy Wootten

Authors:

- Joanne Whalen (insects)
- Mark VanGessel (weeds)
- Bob Mulrooney (plant diseases)
- Susan Whitney King (general information)

References

(1) USDA News Release. NASS. Expectations for 2006 soybean crop shattered by dry weather. September 12, 2006. http://www.nass.usda.gov/Statistics_by_State/Maryland/Publications/News_Releases/mpr11-06.pdf

(2) Crop Profile for Potatoes in Maryland. 2002. http://www.ipmcenters.org/cropprofiles/docs/MDpotato.pdf

(3) Dively, Galen, Entomologist, University of Maryland, College Park. Personal Communication. 1999.

(4) 2008 Commercial Vegetable Production Recommendations: Delaware Cooperative Extension Bulletin E001.

(5) Potato Production in the Northeast: A Guide to Integrated Pest Management. Hollingsworth, C.S., D.N. Ferro, and W.M. Coli, eds. Department of Entomology, University of Massachusetts, Cooperative Extension Service. 1986.

(6) 1999 Commercial Vegetable Production Recommendations: Delaware Cooperative Extension Bulletin 137 (revised). 1999.

(8) Insect Pests of Tomato, Pepper and Eggplant, Pest Management Aid no. 3. University of Maryland Cooperative Extension Service, College Park, Maryland. 1986.

(9) Vegetable Insect Management with Emphasis on the Midwest. Foster, R. and Flood, B., Eds. Meister Publishing Company. 1995.

(10) Integrated Pest Management for Potatoes in the Western United States. University of California, Division of Agriculture and Natural Resources. Publication 3316. 1986.

(11) Bean and Pea Insect Pests 1, Pest Management Aid no. 5. University of Maryland Cooperative Extension Service, College Park, Maryland. 1986.

(12) Insect Pests of Sweet Corn I, Pest Management Aid no. 2. University of Maryland Cooperative Extension Service, College Park, Maryland. 1986.

(13) Maryland Blacklight Trap Program - Twenty Six Year Summary of Selected Pest Periodic Flight Activity. Maryland Department of Agriculture, Anapolis, Maryland. 1999. Courtesy of Dick Bean.

(15) Insect Pests of Sweet Corn I, Pest Management Aid no. 1. University of Maryland Cooperative Extension Service, College Park, Maryland. 1986.