Potatoes

Culture

Potatoes are an important vegetable crop in Ohio and are sold for fresh market, roadside stands and processing. Yields range from less than 200 cwt/A to more than 400 cwt/A and are dependent on variety, planting date, weather conditions, production practices and harvest date.

Production costs may exceed $1,000/A. New growers should give careful study to their soils, availability of water for irrigation, varieties to be grown and where the product is to be marketed. If production is planned for processors, contact the processor or others familiar with the industry for specific suggestions on cultivars and other cultural practices, especially pesticide suggestions.

Ohio growers are in a strategic area for producing potatoes for an expanding market. But to be successful in this region, where temperature during the growing season may not be especially satisfactory for potatoes, growers must observe good cultural practices including field selection and cultivar selection for specific soil and climatic conditions and specific markets.

To be successful, growers must follow good management practices during the growing season and provide extra care at harvest to reduce damage to the tubers. Today's markets, whether for fresh market or processing, require bruise free tubers, a desirable size and good maturity for that specific market.

Potatoes require a well-drained, fertile, sandy loam to silt-loam soil. Heavier soils require the incorporation of deep-rooted legumes, cover crops and special tillage practices. A 2- or 3-year rotation with such crops as corn and legumes will help.

Cultural Practices Affecting Colorado Potato Beetle

The following cultural practices can help prevent problems with Colorado potato beetle. These cultural practices are important because insecticide resistance problems occur when chemicals alone are used for beetle control. Promote rapid emergence and growth of potatoes by selecting a well-adapted cultivar for the site, because larger plants are better able to tolerate defoliation than smaller plants. Planting potatoes in early April can allow the plants to grow through the bloom stage before the beetles arrive in force. Planting potatoes in early to mid-June can allow the potato beetles to leave the area before the potato plants are available. Early maturing varieties should be used for either very early or very late planting to avoid beetle damage. By using early-maturing cultivars and by harvesting as soon as the crop is mature, you can reduce the food source for beetles late in the season which can weaken the beetles for their overwintering phase. Minimize volunteer potatoes by avoiding fall plowing, or by fall plowing followed by a legume cover crop that will outcompete potatoes, or by using a post-bloom sprout inhibitor. Adult beetles can be concentrated during the fall when vine killers are used by skipping 2-4 rows of potato plants for each 100 rows in the field. Beetles that converge on these rows and finish the vine killing can be flamed, vacuumed, or sprayed with a contact insecticide that you don't plan to use the following year.

Varieties

Early Maturing Varieties

Irish Cobbler is an early maturing variety with excellent cooking quality but poor market acceptance due to deep eyes. It is raised for roadside markets and home gardens.

Jemseg is from Canada. It is characterized by rapid vine growth and tuber enlargement. It is suitable for early fresh market, but it may be difficult to grow. Stand establishment may be difficult. Nitrogen fertilizer should be reduced about 25% of normal rate. It must be planted early and it is suitable for sandy-gravely soils. Can be raised for home gardens, roadside markets and commercial use.

Norland is a red-skinned variety, but it is quite sensitive to air pollution (ozone). It is grown for fresh market and roadside selling. New strains of Norland with better red color are available. Suitable for home garden and roadside markets.

Superior does best on well-drained, sandy loam to gravelly loam soils. It is grown for both fresh market and chipping. If scab is a problem, this variety can be tried. The tubers are white, blocky to oblong in shape, with somewhat netted skins at maturity. It is quite susceptible to verticillium wilt and the "early dying" complex. Sidedress application of N can be helpful on light-textured soils. It may go off-shape if harvest is delayed. Suitable for roadside markets and commercial markets including processing.

Conestoga is an early-maturing variety from Canada. It is reported to have some resistance to leaf-roll and scab. Tubers are round, white and tend to be slightly buff. In Ohio tests, specific gravity was similar to Norchip, but other states report high specific gravity. Early planting is essential. This variety seems to do best in light soils and under irrigation. Growth cracks and off-shape can be serious if variety is grown on heavy soils, or weather stress occurs during tuber enlargement stage. Suitable for roadside market, home garden and commercial markets.

Midseason Maturing Varieties

Monona is an early midseason variety grown primarily for the potato chip industry. It is a round, oblong tuber with white skin that tends to be poorly shaped on heavy soils. Its use is declining in chip processing because of low specific gravity and poor tuber shape under some conditions. It is being replaced by other cultivars.

Shurchip, developed in Nebraska, is a medium-early variety; tubers are round and slightly russeted. It carries some scab tolerance and is adapted to light-textured soils. It has high yielding potential with irrigation. It is grown primarily for fresh market. The tubers may have poor shape under high temperatures and lack of moisture. Suitable for home garden, roadside selling and commercial markets.

Norchip is a medium-early variety with round tubers that can become off-shaped under stressful weather conditions. It carries some scab tolerance. It is grown primarily for the potato chip market and for storage for this market.

Atlantic is a high-yielding and high-specific gravity potato, but it is subject to internal discoloration and hollow heart. This variety is not recommended for Ohio conditions unless the grower has a contract with a potato chip company. It is not considered to be a storage variety under Ohio conditions. The internal discoloration is a serious problem under stress conditions. Hollow heart can be a serious problem. It should not be grown for fresh market.

Cultivar	Approximate Days to Maturity
Jemseg	75-85
Norland	80-90
Conestoga	90-100
Superior	90-100
Monona	100-120
Shurchip	110-120
Norchip	100-110
Atlantic	100-115
Katahdin	120-150
Kennebec	130-135

Mid- to Late-Season Varieties

Katahdin, a USDA introduction, is primarily a table stock variety, but it is sometimes used for chipping. The smooth, round white tubers are attractive. Hollow heart can be a problem, and it is fairly susceptible to scab. Planting seed pieces closer will help control tuber size. Hilling is essential to control greening. It is being replaced by new varieties with better market quality and higher yield.

Kennebec is a high-yielding variety with excellent cooking quality. It is susceptible to various diseases, including verticillium wilt and bacterial soft rot in storage. It is susceptible to greening. Due to these problems, it is not suitable for commercial production. It continues to be popular for roadside selling and home gardens. It is declining as a commercial variety because of high grade-out defects.

Russet Norkotah is a promising variety under certain Ohio conditions. Tubers are quite uniform, with an attractive medium russet skin and shallow eyes. Requires irrigation and increased fertility levels. Does best on light-textured soils with irrigation and increased fertility levels, especially nitrogen as sidedress application. This variety does poorly on heavy soils. The search continues for a russet-type potato that is generally suitable for dry land production. This variety should not be grown without irrigation.

Red Pontiac is a late-maturing red-skinned variety used for home gardens and roadside selling. It is a high-yielding variety, but tuber cracking and shape are problems. New red varieties should be tried. It usually has poor appearance.

Varieties for Trial Planting

Many new cultivars are being released, but they should be tested for at least 2 years on individual farms before extensive acreages are planted.

During the past several years, more than 200 cultivars have been evaluated annually in the Ohio trials at the Ohio Agricultural Research and Development Center and on cooperative farms in Ohio. Promising cultivars include:

Norwis (FL 657) has been included in the Ohio trials since 1990. The tubers are round to slightly oval with a light cream appearance and with a light netting. The appearance is good and the variety may be suitable for fresh market. Limited tests indicate it has high yielding ability, but must be grown on light-textured soils. If grown on loam soil, it gets irregular surface. Surface scab can be a problem. The tubers develop rapidly and may offer possibilities for early markets. Plant early on light textured soils (sandy and gravely). Suitable for roadside selling, home garden and commercial markets.

Snowden was developed at the University of Wisconsin and has been evaluated under Ohio conditions. The tubers are round and with a medium buff to light buff appearance, and the eyes are shallow. The tubers tend to be small. It could have yielding ability if tuber size could be increased. Apical end tends to be deep. Spacing seed pieces at 12 inches may help increase size. Some internal problems have been observed. For processing market.

Langlade was developed by plant breeders at the University of Wisconsin. The tubers are round to oval with a smooth, light-buff appearance and some netting. It has yielding ability, but there is a tendency for large tubers. Spacing at 8 inches or closer may help control tuber size and hollow heart.This variety seems to do well over a wide range of soil textures. Suitable for home garden, roadside selling, and commercial markets.

Crop Rotation

Crop rotation is one of the most important tactics for avoiding and reducing problems with Colorado potato beetle. Rotating potato fields with non-solanaceous crops (crops other than potato, tomato, eggplant, or pepper) can delay and reduce infestations by first brood potato beetles. New fields should be as far as possible from the previous year's fields, ideally at least 1/4 mile. Although some beetles will still fly to these fields and additional control will likely be necessary, control tends to be easier and more successful and resistance problems are less likely where fields were rotated far from the previous year's crop.

Lime and Fertilizer

Because scab may be a problem, maintain soil pH at 5.4 or slightly more acidic. Scab-resistant varieties, such as Superior, can tolerate more alkaline (higher pH) conditions. Unless soil pH is below 5.0, do not apply limestone immediately before planting; apply after harvest. Dolomitic lime is used where magnesium levels are low, especially in eastern Ohio. In such areas, use a soluble source of magnesium, such as magnesium sulfate, in the fertilizer applied at planting. Where magnesium may be needed, applying 30-40 lb MgO per acre will help. A three-year rotation will help reduce scab. A three-year rotation without potatoes will help to minimize scab problems after a moderate lime application. Fields with a history of scab should be avoided.

Mineral soils: Apply per acre 100-150 lb of N on clay and fine textured soils and 170-180 lb on coarse textured soils (sands, etc.)

Phosphorus and potassium rates are best determined by soil test. Due to shallow-limited root system, phosphorus should be placed near seed. Inadequate N can reduce yields, and too much N can affect tuber quality, storage characteristics of the variety and potential for rot in the market. N rates vary depending on variety. The N rates in the table on the next page should be adjusted based on previous experience.

Apply 2/3 of the fertilizer in bands at planting. The bands should be 2-3 inches to the side and below the seed pieces. An additional 30-40 lb N may be needed as a sidedress application when plants are 4-6 inches tall.

Muck soils: Apply per acre 75-100 lb N and 100-150 lb each of P_2O_5 and K_2O. Use a soil test to determine exact phosphorus and potassium needs. On shallow muck, the fertilizer should be banded at planting time. On deep muck, it can be either banded or broadcast applied prior to planting. Some varieties may need additional nitrogen fertilizer as a sidedress application.

Variety	Tablestock Market N lb/A	Chip Market N lb/A
Katahdin	150-170	
Kennebec	110-120	
Superior	160-190	
Norland	160-180	
Jemseg	90-100	
Norchip		160-180
Monona	120-150	
Atlantic		150-180

Seed Handling, Planting and Spacing

Many changes have occurred in the various regions where certified seed is produced. Depending on the region, there may be as many as five or seven generations of seed from the laboratory to the field. Growers should arrange with their supplier to purchase seed depending on the disease readings made by the certifying agencies. Successful potato production depends on good, certified seed and proper seed handling on the individual farm.

Most seed is shipped in bulk. If the seed tubers are received in bags, leave space between pallets for air movement, and do not store bagged seed more than two pallets high. Warm the seed several days before planting so that pulp temperature will be 55° F to 60°F at planting. Warming the seed will aid rapid emergence of the sprout.

For many years, the usual procedure was to cut the seed, treat with a suitable fungicide, and plant immediately. This is still a good practice where soil conditions are ideal at planting, no rains occur for several weeks following planting, and when seed pieces are not likely to decay in soil. Unfortunately some new varieties are quite susceptible to seed piece decay when the "cut-and-plant" approach is followed.

In many potato-growing areas today, the suggested procedure is to cut the seed, cure the seed so that a suberin layer has been formed, then cool the seed until planting. Several days before planting, warm the seed so pulp temperature will be 55° F to 60°F.

To hasten the healing of cut seed, hold the cut seed at 50°F to 60°F and with high humidity for 3 to 4 days. With bulk seed, it is important to have air movement through the pile during this period. Under Ohio conditions, it generally is not necessary to add additional moisture to the air being forced through the pile. If the cured seed can't be planted after the healing period, lower the temperature to 40°F to 45°F until time for planting. For best results, potatoes should be sprouting at planting time, but sprouts should not be so long that breakage will occur in the planting operation.

When cutting seed, disinfect the cutter before use and between each seed lot (see "Ring Rot," page 209). Some growers will inspect the seed on the conveyor as the bulk load is being moved into farm storage. Tubers showing decay should be removed. With the presence of late blight in most seed producing areas, growers should be extra careful when purchasing seed. It would help to minimize the chance of getting the disease by grading the seed after cutting. Any seed piece with a reddish to brown area should be discarded.

The ideal seed piece should weigh 1.5-2 oz., contain one to two eyes, and be treated with a suitable fungicide.

Amount of Seed Needed for One Acre						
Spacing of Seed in Row	34-inch rows			36-inch rows		
	Weight of Seed Pieces (oz)					
	1.5	1.75	2.0	1.5	1.75	2.0
	cwts					
8	22	25	29	20	24	27
10	17	20	23	16	19	22
12	14	17	19	14	16	18
15	11	14	16	11	13	14

Previous experiences are important guides for seed piece spacing. Closer spacing may be helpful if hollow heart, large tubers, or tubers tending to have poor shape are used.

One of the major decisions which a grower must make involves spacing of seed pieces. Most markets will penalize growers if tubers have a diameter greater than 3 inches. One of the factors affecting size of tubers at harvest is the distance between seed pieces at planting. It may be necessary to space seed pieces of new cultivars closer than previously with older cultivars. Closer spacing may be also needed if irrigation is available.

The following guide offers some suggested spacing for major varieties:

Jemseg	9-10 inches
Superior	9-12
Norland	10-12
Shurchip	9-12
Monona	8-9
Atlantic	8-10
Katahdin	8-9
Kennebec	8-9
Norchip	10-12
Langlade	6-8

Planting Dates

Southern Ohio: late March to late April.

Central Ohio: early April to mid-May.

Northern Ohio: late April to mid-June.

Planting dates vary from season to season and according to specific soils and varieties. Planting should be done as early as possible, as soil conditions permit.

Cultivation and Hilling

By using recommended herbicides, cultivation can be delayed until plants are established. Cultivate to break the crust on certain soils and to improve aeration.

The hilling operation should be completed before plants start blooming. A well-built hill helps to control weeds, protect from late blight and prevent greening. Hilling seems to be highly desirable for most varieties under Ohio conditions, but is especially important for Katahdin, Shurchip, Norchip and Kennebec.

Sprout Control

Maleic hydrazide (Royal MH-30 or Super Sprout-Stop) is labeled for use in the field to control sprouting. Apply where most tubers are at least 2 inches in diameter or about 1-2 weeks after blossom drop. Vines must be green and actively growing. Apply when no irrigation or rainfall is expected for 24 hours. See the product label for more details.

CIPC (Sprout Nip) must be applied in the storage after cuts and wounds have healed. Effectiveness depends heavily on the availability and proper use of an adequate through-the-pile distribution system in the storage. Treatment is performed by certified custom applicators.

Vine Killing

Vine killing is an essential step in potato production. In addition to the desirable effects on storage quality, vine killing facilitates harvest and prevents possible disease problems.

Vascular discoloration in the tubers can occur when vines are killed rapidly, especially when temperatures are high and soil moisture low. To minimize vascular discoloration, use low rates of chemicals or split applications, if labeled, in hot, dry weather. Use higher rates during cool weather.

Diquat at 0.25 lb a.i./A (1 pt Diquat—2.0 a.i./gal), with a suggested surfactant such as X-77 or a similar nonionic adjuvant, has given good results in Ohio. Apply at least 7 days before harvest. Apply in 20-100 gallons of water per acre. Where vine growth is dense, make a second application at the same rate. Allow at least 5 days between application. Do not apply to drought-stressed potatoes. Follow the label instructions. Use clean water. For best results, apply in evening.

With rapid-growing potato vines, there may be an advantage in using a vine killer such as endothall (Desicate II). The rate of kill is slower with this product. Apply Desicate II 1.5-2.0 qt/A 10-14 days prior to harvest. Add to the spray tank

4-5 pounds per acre of dry ammonium sulfate plus a surfactant. Any dry or liquid formulation of ammonium sulfate can be used at the manufacturer's recommended rate. Be sure that the ammonium sulfate is thoroughly dissolved in the tank before adding Desicate II. Use the higher rate of Desicate II for vigorous vine growth or when weather conditions are cool and cloudy. Do not use less than 5 or more than 40 gallons of water per acre. Follow label directions.

Growers should continue application of fungicides until foliage is dead to prevent development of late season late blight, which might infect tubers at harvest.

Harvesting and Storage

Ohio growers often experience a substantial loss of their potato crop due to mechanical damage at harvest, field frost or storage rot. A major part of the loss can be traced to a lack of attention to details in harvesting and handling.

Several suggestions:

1. Tubers should be mature and vines should be dead at harvest. Too much nitrogen fertilizer can delay maturity.
2. Try to avoid harvesting when soil temperature is below 50°F. If field frost occurs, and time permits, allow a few days for frosted tubers to develop symptoms so they can be graded out prior to storage. Store frosted tubers separately.
3. Maintain a cushion of soil as far up the primary digger chain as possible, while still allowing for good separation. This may require pulling the harvester faster or deeper than normal or reducing agitation in sandy or dry soils. Operate the harvester at capacity at all times. Chains should be full to prevent tuber roll-back and bounce.
4. Use rubber-covered chains and cushion all points of impact. Minimize all drops to not more than 6 inches.
5. Before placing potatoes in storage, clean the storage thoroughly. Run the storage ventilation system through two or three complete ventilating-recirculating-humidifying cycles to be sure all controls are working properly before receiving the first load of potatoes for storage. Disinfect storage if significant disease occurred the previous year (see "Ring Rot," below).
6. Cure both chipping and tablestock potatoes at 55-60°F and at high relative humidity (90%-95%) for 10 days after harvest to promote healing of cuts and wounds. Adequate air movement is essential during this curing period. After curing, cool table-stock gradually to 38-40°F and maintain high humidity (90%-95%); hold chipping potatoes at 50-55°F, unless experience with a given variety under specific conditions indicates a lower temperature can be maintained.
7. Severely blighted or frosted potatoes are difficult to store successfully and should be separated from sound potatoes by a wall or partition or stored in a separate building. Such potatoes should be sold as soon as possible. The tubers should be cooled to 38-40°F by circulating air (0.5 cfm/cwt) through the pile. Relative humidity should be lowered in order to dry the potatoes more rapidly.

Disease Control

Ring Rot

Use certified disease-free seed. When cutting seed stock, the cutter should be periodically cleaned and disinfected. Under no circumstances should a seed lot change be made without cleaning and disinfecting the cutter.

Ring rot is caused by a bacterium that is very contagious. Although this bacterium will not survive more than 1 year in the soil and thus can be controlled by crop rotation, a farm with ring rot must conduct a thorough clean-up before bringing in seed for the next year's crop. The organism can easily survive the winter in dried slime or soil on storage walls; seed cutters, bin pilers, graders and other handling equipment; tractors, fork lifts and other vehicles; and on burlap sacks, wooden boxes or other containers.

If clean seed potatoes come in contact with any of these sources of contamination, the problem can recur. The first step is to clean all contaminated surfaces with hot soapy water to remove all soil and debris. Use steam or water under pressure. However, this alone will not eliminate the bacterium. The surfaces then must be treated with a disinfectant.

Many disinfectants are available on the market. The table below summarizes effectiveness of disinfectants. All compounds were tested at recommended rates unless indicated otherwise.

In selecting a disinfectant, one must consider cost, availability and hazard to the applicator. Formaldehyde, although very effective, is hazardous and must be used with protective clothing and equipment. In all cases, follow label directions carefully. It is essential that all surfaces be cleaned before the disinfectants are used, because dirt and debris will inactivate them.

Disinfectants should be allowed to stand on the surfaces to which they are applied for 15-20 minutes, preferably longer, and then rinsed off completely with clean water.

Effectiveness of Disinfectants for Control of Ring Rot Bacteria			
Disinfectant	**Metal**	**Wood**	**Burlap**
Betadine[1]	g	g	g
Chlorine bleach (10%)	s	s	g
Coal Tar	g	g	g
DeBac[2]	g	g	g
Ethyl alcohol (95%)	s	g	g
Formaldehyde (1%)	s	g	s
Formaldehyde (2%)	g	g	g
Formaldehyde (4%)	g	g	g
Vesphene[1]	u	u	s
Zephiran[2]	g	g	g
Lysol concentrate	u	u	s
Lysol spray	s	g	s
Phenol (5%)	s	s	s
Water	u	u	u
Soapy water	u	u	u

[1] Hospital disinfectant.
[2] Quarternary ammonium compound.
g = good control after 15-20 minutes.
s = very slight survival of bacteria after 15-20 minutes.
u = unacceptable control.

Seed Piece Decay, Silver Scurf, Black Scurf

Treat seed pieces with one of the following:
Maneb 8% dust at 1 lb/cwt.
Tops MZ 0.75 lb/cwt.
Maxim MZ 8 oz/cwt.

Many growers are having success with seed piece treatment fungicides formulated on pulverized fir or alder bark as this carrier is superior at drying cut tuber surfaces.

In-furrow treatments:
Quadris F 0.4-0.8 oz/1,000 row ft in furrow.
Moncut 0.71-1.1 lb/A. Apply as an in-furrow spray over seed pieces.

Early Blight (Alternaria) and Late Blight (Phytophthora)

Starting when plants are 8-10 inches high, apply one of the following fungicides at weekly intervals. During cool, wet weather, applications at 5-day intervals may be necessary. Follow label directions, including rotation restrictions.
Bravo Weather Stik 1-1.5 pt/A (7 days-PHI).
Equus 720 0.75-1.5 pt/A (7 days-PHI).
***Gavel 75DF** 1.5-2.0 lb/A (3 days-PHI).
Mancozeb 75DF 2-3 lb/A (5 days-PHI).
Maneb 75DF 1.5-2 lb/A (3 days-PHI).
Seasonal use of Dithane M-45 has been reduced to 14 lb/A.
Rovral 4F 1-2 pt/A. Maximum 4 applications (14 days-PHI) (Early blight only).
Fixed copper fungicides: Several types of fixed copper products are labeled for potatoes. Check label for rates and restrictions.
***Quadris** 6.2-15.4 fl oz/A (14 days-PHI).
***Quadris Opti** 1.6 pt/A (14 days-PHI).
***Tanos 50DF** 6-8 oz/A (14 days-PHI). Must be tank-mixed with a protectant fungicide.
***Endura** 2.5-4.5 oz/A (Early blight only).
***Acrobat MZ** 2.25 lb/A (14 days-PHI) (Late blight only).
***Ranman** 1.4-2.75 lb/A (7 days-PHI) (Late blight only).
***Omega** 500 F 5 fl oz/A (14 days-PHI) (Late blight only).

Tuber rot and storage rot (Phytophthora rot and Pythium leak) **Ridomil/Bravo** 2 lb/A. Apply at flowering and again 14 days later as a substitute for regularly used fungicide. Use in fields where tuber wet rots have been a problem.

Botrytis Vine Rot

This disease is generally a problem only under irrigation. If significant disease develops, apply:
Bravo Weather Stik 0.5-1.5 pt/A (7 days-PHI).
Equus 720 1.0-1.5 pt/A (7 days-PHI).

Scab

Keep soil pH below 5.5 and do not apply manure to fields used for potato production. Varieties differ greatly in susceptibility to scab. Know the varieties and the field history before planting. If irrigation is available, provide adequate moisture during tuber formation.

Fusarium Dry Rot of Tubers in Storage

Avoid bruising and excessive soil on tubers. When placing crop into storage, apply **Mertect** 340-F as fine mist as potatoes pass over bin loader or conveyor. See label directions. Avoid cuts and bruises and excessive soil on tubers and in storage. Maintain a proper storage environment so that suberization can occur quickly.

Mosaic, Leafroll, Purple Top and Other Virus Diseases

Plant certified seed potatoes only. Control aphids and leafhoppers.

Nematodes

Preplant fumigation may be useful in some situations (see "Soil Fumigation" on page 61). The following may be applied at planting: **Vydate L** 1-2 gal in 20 gal water/A or **Mocap 15G** 20 lb/A or **Mocap EC** 2 qt/A. See product label for application directions.

White Mold

***Omega 500 F** 5.0-8.0 fl oz/A (14 days-PHI).
***Topsin M** 70WP 1-1.5 lb/A (21 days-PHI).
***Endura** 5.5-10.0 oz/A (30 days-PHI).
Contans WG 2-4 lb/A in 50-100 gal water. Apply immediately after harvest or 3-4 months before planting.

Black Dot

***Tanos** 6-8 oz/A, tank mixed with protectant fungicide such as Manex (14 days-PHI). Disease suppression only.

*Follow guidelines for fungicide resistance management on the product label (see pages 59-60).

Insect Management

Biological Control

Natural enemies can provide adequate biological control of *aphids* if broad-spectrum insecticides are not used, particularly after mid-July. Common natural enemies in Ohio are lady beetle adults, lady beetle larvae, lacewing larvae, hover fly larvae, damsel bugs, minute pirate bugs, and parasitic wasps.

Several natural enemies of the *Colorado potato beetle* can help suppress populations, but none has yet been found that alone can adequately control populations of this pest. A lady beetle feeds on eggs of potato beetles, and several parasitic flies and a fungus can attack the population. These natural enemies may be conserved by planting of New Leaf potatoes or application of microbial insecticides such as B.t. that are toxic to the Colorado potato beetle but not to beneficial insects. Research is underway to test the usefulness of exotic parasitoids that can be reared in laboratories then released in potato fields, but none has yet been found to be effective enough on potato to be developed for commercial use.

Mechanical Controls

A very high volume crop vacuum can be used to suck potato beetle larvae and adults off of plants. In typical designs that are commercially available, the beetles are pulverized before exiting the vacuum device. Propane flamers can be used to kill adult beetles on small plants during spring and on bare vines during fall. Peak temperatures above 212 degrees F cause greater than 80% kill at low per acre cost for the propane fuel. Propane burners, however, are useful only before the plants are approximately 8 inches tall and at vine killing time. Beetles are often concentrated on the edge of a new field in the spring if it is planted relatively early and close to a previous year's field. When concentrated, adult beetles can be flamed or vacuumed efficiently. Beetles also congregate on any remaining green foliage after a field is vine killed and can be flamed or vacuumed more efficiently there (see cultural practices on page 204).

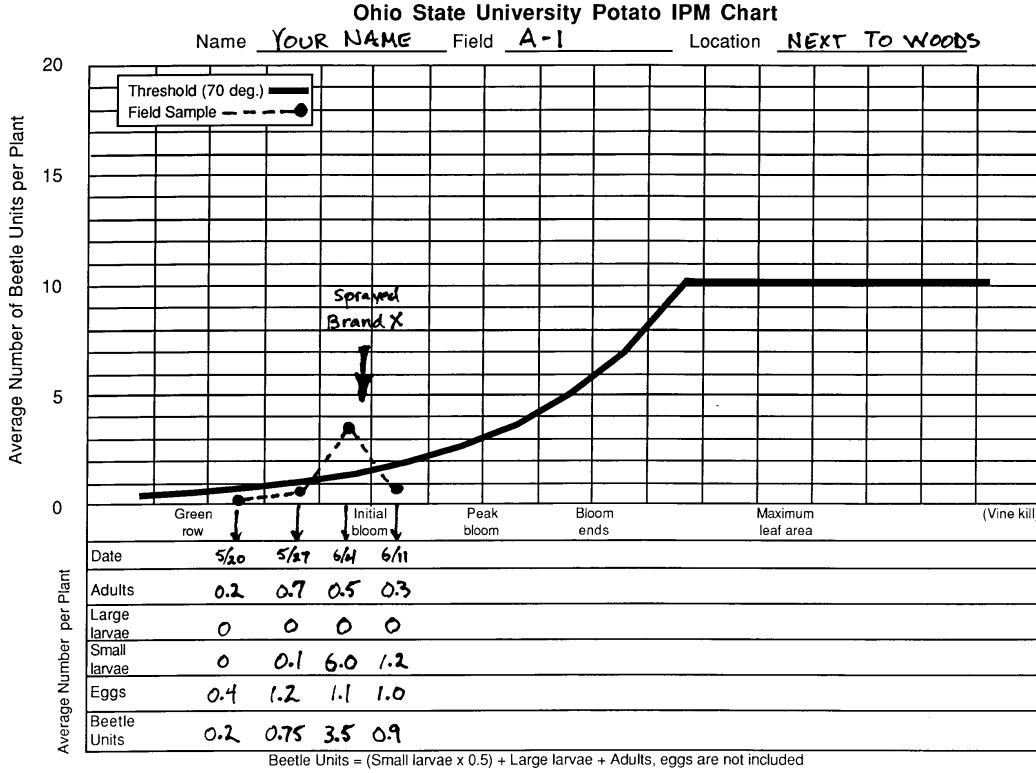
Scouting for Colorado Potato Beetle

The scouting procedure described here was developed in Ohio between 1990 and 1992 and refined by growers participating in an IPM pilot project.

1. Examine 30 randomly selected young plants (before green row) or 15 older plants per field. When rows fill in and plants become intertwined, inspect 15 one-foot lengths of row from row-center to row-center.
2. For each plant, count the number of beetles in four categories: egg masses, small larvae (< 3/16 inch), large larvae (> 3/16 inch), and adults.
3. Add up the totals for each of the four categories and divide by the number of plants sampled to get the average number per plant.
4. Convert the sub-totals into a single number of Beetle Units:

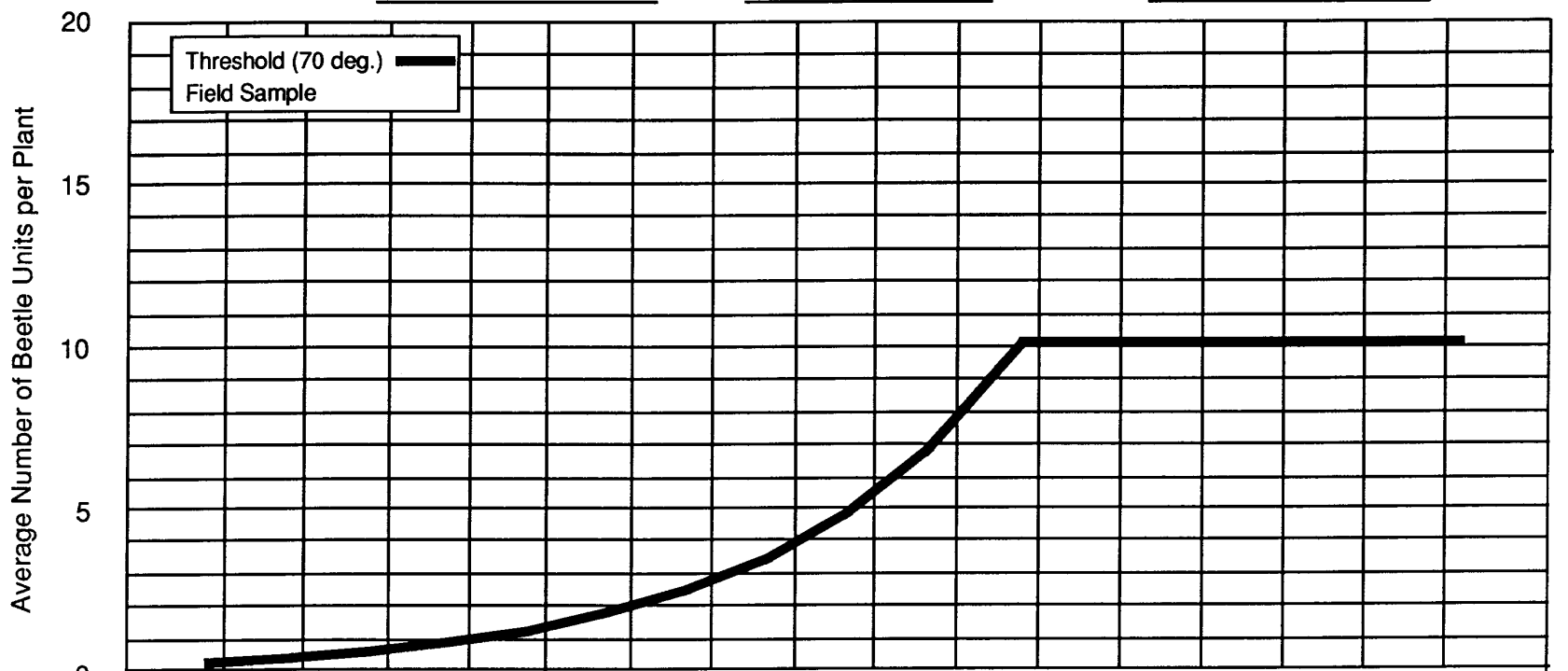
number of small larvae	=	____	x	0.5	=	____
number of large larvae	=	____	x	1.0	=	____
number of adults	=	____	x	1.0	=	____
				total	=	____

5. Plot your total number of Beetle Units on the graph on page 213 for the appropriate growth stage. If your point falls below the threshold line, treatment is not needed. If your point falls above the threshold line, treatment is suggested to prevent yield loss. Connect the points over time to keep track of your progress. In the example below, no spray was required until June 4. Write in your sprays with an arrow showing when they were applied.



Ohio State University Potato IPM Chart

Name _____ Field _____ Location _____



Average Number per Plant													
Date													
Adults													
Large larvae													
Small larvae													
Eggs													
Beetle Units													

Beetle Units = (Small larvae x 0.5) + Large larvae + Adults, eggs are not included

Scouting for Potato Leafhopper and Aphids

In late June you must be alert to leafhoppers, aphids, and cutworms moving into your fields, especially right after alfalfa has been cut.

1. Use a sweep net to make 10 sweeps across the top of the potato canopy in each of 5 areas of the field. Count the number of adult leafhoppers caught in each 10-sweep sample. Calculate the average number of leafhoppers per sweep.
2. Count the number of aphids and leafhopper nymphs on one compound leaf in the lower canopy on each of 30 plants.

Treat if you find an average of 2 or more aphids per leaf before tuber initiation or more than 4 aphids per leaf from tuber initiation to 2 weeks before vine kill.

A general threshold rule for potato leafhopper is to treat if the average number of leafhopper nymphs is at least 0.1 per leaf or if there was at least 1 leafhopper adult per sweep in the sweep net sampling.

A more specific rule for leafhopper thresholds is:

If adult count per sweep is:	**then**
< 0.5	treat only if ≥ 0.1 nymphs/leaf
0.5-1	treat if nymphs present and adults present for > 2 weeks
1-1.5	treat immediately if nymphs present, or within 1 week if nymphs not present
> 1.5	treat immediately

Wireworm monitoring

Wireworms can attack potato tubers, especially when potatoes are rotated with wheat. Fields can be monitored by baiting in fall or spring when soil is moist and temperature at 6-inch depth is at least 45 degrees F. Use at least 25 baits for each 30 acres; each bait is a fist-sized portion (1/2 cup). Choose a sprouting or fermenting material for the bait: coarse chopped carrots or potatoes; whole wheat + bran (1:1 mix); oatmeal; wheat seed or wheat flour. Bran or flour baits can be wrapped in nylon stockings to make packets. Bury each bait 4 to 6 inches deep, cover with soil, and mound the soil up to promote rain run off. If done during a cool spring, cover each bait station with a piece of black plastic to act as a solar heater. Randomly select locations across the field to locate the bait stations. If parts of the field have a different history, such as half in pasture and half in corn, then set up baits in each half and keep track of the two halves separately. Flag each location so it can be found again. Dig up baits after 5 to 10 days and examine for wireworms. Count the number of wireworms in each bait station, then calculate the average number per station. Risk of economic damage is moderate if there are 0.5-2 wireworms per bait station, or high if an average of > 2 per station.

Insecticides

See the table on the next page for overview of insecticides used to control potato pests.

Insecticide rotation: The Colorado potato beetle can develop resistance to insecticides. In areas of intensive potato production where insecticides have been heavily used, beetle populations are resistant to nearly all insecticides. Resistance to one chemical is often accompanied by resistance to related chemicals.To avoid or delay the buildup of resistance in Colorado potato beetle populations, *insecticide classes should be rotated between beetle generations.* See the table on the next page for materials included in each of the four major classes: organophosphates, carbamates, organochlorines, and pyrethroids. Other classes are biologicals (B.t.), inorganics (cryolite), and miscellaneous (rotenone). As a rough guideline for typical Ohio weather: Eggs and larvae of the first generation are present from early June to early July; adults of the first generation are present during July; eggs and larvae of the second generation are present in late July, August, and September; and adults of the second generation are present in August and September and May and early June of the following year. Therefore, use different classes of insecticides against larvae during June and early July than you do against larvae in late July and August or adults in May of the following year.

Use of synergists: Piperonyl butoxide (PBO), which is sold as Butacide 8EC, Incite 8EC, or Prentox PBO-8, is sometimes recommended as an additive to insecticides for control of Colorado potato beetle. PBO can improve the efficacy of the insecticide by preventing resistance if the pest population has developed a certain type of resistance. PBOs will not improve efficacy in non-resistant populations or in populations with a resistance mechanism not affected by PBOs.

Susceptibility of life stages: For most insecticides, small larvae of Colorado potato beetle are most susceptible, large larvae are intermediate in susceptibility, and adults are least susceptible. Insecticides are thus likely to be more effective if applied when most of the pest population is in the early larval stage.

Insecticides for Use on Potatoes in Ohio

(E = excellent; G = good; F = fair; P = poor; ✓ = pest listed on label but efficacy uncertain; - = pest not on label; rating in parentheses = pest not on label but product known to provide some control)

Pest >>	**Pre-harvest interval (days)**	**Wire-worms**	**Cut-worms**	**Colorado potato beetle**	**Flea beetle**	**Leaf-hopper**	**Aphids**	**Euro-pean corn borer**	***Impact on beneficial insects***
How often an insecticide has been needed on Ohio farms for this pest in the past>>		occa-sional	occa-sional	every year	occa-sional	every year	occa-sional	occa-sional	
ORGANOPHOSPHATES									
diazinon	35	✓	✓	-	-	-	-	-	moderate
dimethoate (Cygon)	0	-	-	-	-	G	G	-	disruptive
Di-Syston (disulfoton)	30	-	-	✓	✓	✓	G	-	moderate
Imidan (phosmet)	7	-	-	F/G*	G	F	-	-	moderate
malathion (Cythion)	0	-	-	-	(G)	F	F	-	low/moderate
Mocap (ethoprop)	-	G	-	-	-	-	-	-	low
Monitor (methamidophos)	14	-	G	P	G	G	G	G	disruptive
Penncap-M (methyl parathion)	5	-	F	P	G	F	(F)	G	disruptive
Thimet (phorate)	-	✓	-	F	G	G	P	-	low
CARBAMATES									
Furadan (carbofuran)	14	-	-	P**	G	✓	-	✓	disruptive
Lannate (methomyl)	6	-	G	-	G	G	G	-	disruptive
Sevin (carbaryl)	7	-	F	P/F**	G	G	-	✓	disruptive
Vydate (oxamyl)	7	-	-	✓	✓	✓	✓	-	disruptive
ORGANOCHLORINES									
Telone (dichloropropene)	-	✓	-	-	✓	✓	-	-	moderate
Thionex, Phaser (endosulfan)	1	-	-	F/G*	G	F	G	✓	moderate
PYRETHROIDS									
Asana (esfenvalerate)	7	-	G	F/G*	G	G	F	✓	disruptive
Baythroid (cyfluthrin)	0	-	-	F/G*	G	G	-	✓	disruptive
Brigade (bifenthrin)	21	✓	-	-	-	-	-	-	disruptive
Decis (deltamethrin)	3	-	✓	✓	✓	✓	-	✓	disruptive
Mustang (zeta-cyper.)	1	-	-	✓	✓	✓	-	✓	disruptive
Pounce (permethrin)	14	-	G	F/G*	G	G	F	✓	disruptive
NEONICOTINOIDS (CHLORONICOTINYLS)									
Actara (thiamethoxam)	14	-	-	G	(G)	G	(G)	-	low/moderate
Admire (imidacloprid)	-	-	-	G	F	F	G	-	low/moderate
Assail (acetamiprid)	7	-	-	G	G	G	G	F	low/moderate
Clutch (clothianidin)	14	-	-	✓	-	✓	✓	-	low/moderate
Platinum (thiamethoxam)	-	-	-	G	G	G	G	-	low/moderate
Provado (imidacloprid)	7	-	-	G	(F)	P	G	-	low/moderate
Venom (dinotefuran)	7	-	-	✓	✓	✓	✓	-	low/moderate
OTHER INSECT NERVE POISONS									
Agri-Mek (abamectin)	14	-	-	G	-	-	-	-	low/moderate
Avaunt (indoxacarb)	7	-	-	✓	-	-	-	✓	low/moderate
Beleaf (flonicamid)	7	-	-	-	-	-	✓	-	-
Fulfill (pymetrozine)	14	-	-	-	-	-	E	-	low
Pyronyl, PyGanic (pyrethrins)	0	-	-	✓	G	✓	✓	✓	moderate
Radiant (spinetoram)	7	-	-	✓	-	-	-	✓	-
SpinTor (spinosad)	7	-	-	G	(F)	-	-	✓	low
MISCELLANEOUS									
B. thuringiensis caterpillar strains (DiPel, etc.)	0	-	F	-	-	-	-	✓	low
B. thuringiensis coleoptera strains (Novodor)	0	-	-	G	-	-	-	-	low
cryolite (Kryocide)	0	-	(F)	G	(F)	-	-	-	low
Neemix, Aza-Direct (azadirachtin)	0	-	-	G	✓	✓	✓	-	moderate
Oberon (spiromesifen)	7	-	-	-	-	-	-	-	-
Rimon (novaluron)	14	-	-	✓	-	-	-	✓	low
soap (M-Pede)	0	-	-	-	-	F	F	-	low

* = some Ohio populations resistant.
** = most Ohio populations resistant.

Spot treatment: Infestations by first-brood larvae are often clumped rather than evenly distributed throughout a field. When infestations are localized along a field edge or in certain areas, edge sprays or spot treatment of infested plants can provide adequate control of the population.

• Seed treatment

Imidacloprid
For aphids, Colorado potato beetle, flea beetles, leafhoppers, wireworms.
Admire Pro (4.6F): 0.17-0.35 fl oz per 100 lb seed (3.5-7 fl oz/A).
Admire 2F: 0.4-0.8 fl oz per 100 lb seed (8-16 fl oz/A).

Thiamethoxam (14 days-PHI)
For aphids, Colorado potato beetle, flea beetles, leafhoppers.
Cruiser 5FS: 0.11-0.16 fl oz per 100 lb of potato seed tubers.

• Preplant soil treatment

Diazinon
For cutworms, wireworms.
Diazinon AG500 (4EC): 2-4 qt/A. See Ohio special local needs label (24c).

Dichloropropene
For wireworms and garden symphylan.
Telone II (94% a.i.): 18-36 gal/A.

Disulfoton
For aphids, flea beetles, leafhoppers. Broadcast and incorporate 2-3 inches.
Di-Syston 15G: 20-26.7 lb/A.
Di-Syston 8EC: 3-4 pt/A, for aphids only.

Ethoprop
For wireworms and garden symphylan.
Mocap 6EC: 2.7-4 qt/A.
Mocap 15G: 27-40 lb/A.

Oxamyl
For flea beetles, Colorado potato beetle, leafhoppers, aphids.
Vydate 2SL: 2-4 gal/A.

• At-planting treatment

Bifenthrin (21 days-PHI)
For wireworm, white grubs.
Brigade 2EC: 19.2 fl oz/A. Apply in-furrow or in T-band.

Dinotefuran
For Colorado potato beetle, flea beetle, aphids, leafhoppers.
Venom 70SG: 6.5-7.5 oz/A. Limit 7.5 oz/A per year.

Disulfoton
For aphids, flea beetles, Colorado potato beetle, leafhoppers.
Apply in furrow, or inject in soil; also can be sidedressed after emergence.
Di-Syston 15G: 15-23 oz/1,000 ft.
Di-Syston 8EC: 2.25-3.5 oz/1,000 ft.

Ethoprop
For wireworms and garden symphylans.
Mocap 6EC: 4.4 oz/1,000 ft.
Mocap 15G: 1.4 oz/1,000 ft of row.

Imidacloprid
For Colorado potato beetle, aphids, leafhopper, flea beetle.
Admire 2F, Alias 2F: 0.9-1.3 fl oz/1,000 ft of row.
Admire Pro (4.6F): 5.7-8.7 fl oz/A.

Note: When applied in-furrow, imidacloprid is a true systemic that will move throughout the plant. It will control

potato beetle from emergence until approximately 50 days later. Time may be shorter on soils with high organic matter or longer when plants are growing slowly. The manufacturer's recommended rate is 1 pt/A for 34-inch rows. Its use does require modifications to planting equipment so that a liquid can be applied in-furrow. A kit for adapting a planter so that it can apply liquid Admire is available from: Custom Ag Products, Inc., P.O. Box 186, Benson, MN 56215; phone 800-225-8082. University trials have demonstrated *equal efficacy* against the entire first generation of Colorado potato beetle with two foliar applications of Provado (see page 219). This approach uses half the amount of active ingredient as the at-planting treatment and is suggested to be less likely to result in resistant Colorado potato beetles.

Oxamyl
For flea beetles, Colorado potato beetle, leafhoppers, aphids.
Vydate 2SL: 1-2 gal/A.

Phorate
For flea beetle larvae, Colorado potato beetle, leafhoppers, aphids, wireworms.
Can also be banded on each side of row. Use high end of rate for Colorado potato beetle.
Thimet 20G, Phorate 20G: 11-17 oz/1,000 ft.

Thiamethoxam
For Colorado potato beetle, aphids, potato leafhopper, flea beetles.
Platinum 2SC: 5-8 fl oz/A.

• Bait treatment

Carbaryl (0 days-PHI)
For cutworms, armyworms.
Sevin 5B: 20-40 lb/A or 7.3-14.7 oz/1,000 sq ft.
Prozap Sevin 10% Bait Granules: 10-20 lb/A.

Metaldehyde
For slugs.
Deadline MP (4B): 20-40 lb/A.
Prozap Snail and Slug AG (3.5B): 24-40 lb/A.

Permethrin (7 days-PHI)
For crickets, cutworms.
Ambush 0.5% Bait: 20-40 lb/A.

• Foliar treatment

Abamectin (14 days-PHI)
For Colorado potato beetle.
Agri-Mek 0.15EC, Abba 0.15EC: 8 fl oz/A. Limit 32 fl oz/A per crop. Apply when 50% of eggs have hatched. Second application might be needed 10-14 days later.

Acetamiprid (7 days-PHI)
For eggs of European corn borer.
Assail 30SG: 1.5-2.5 oz/A.

Azadirachtin (neem) (0 days-PHI)
For Colorado potato beetle larvae, leafhopper nymphs.
Neemix 0.25% a.i.: 0.5-2 gal/A.
Neemix 4.5 (4.5% a.i.): 0.125-1 pt/A.
Azatin EC (0.265 lb a.i./gal): 10-21 fl oz/A.
Azatin XL Plus (0.265 lb a.i./gal): 10-16 oz/100 gallons.

Azinphos-methyl
NOTE: Guthion is not allowed for use on potatoes after September 30, 2006.

***Bacillus thuringiensis* (B.t.)** (0 days-PHI)
For Colorado potato beetle.

Note: Use when beetle larvae are just hatching. During first generation egg hatch, threshold will be reached if 2 hatching egg masses are found on a random 30-plant sample. For optimal timing to control the second generation during July and August, treatment may be required before population reaches threshold.

Note: If you use B.t. for controlling Colorado potato beetle, it is best to apply it alone rather than as a tank mix with a conventional insecticide. If an insecticide is needed for aphid control, it is best to wait and apply it at least 1 day after B.t. Reduced efficacy of B.t. when tank mixed with Monitor was recently documented on Long Island; although Monitor was not toxic enough to kill beetles, it apparently made the beetles sick enough to slow down their feeding during the time that B.t. residues were freshest and most active. If B.t. is used for beetle control, insect natural enemies often control aphids at no additional cost, although sometimes more slowly.
Novodor FC (3% a.i.): 1-4 qt/A.

***Bacillus thuringiensis* (B.t.)** (0 days-PHI)
For loopers, armyworms, cutworms, other caterpillars.
Agree WG (3.8% a.i.): 1-2 lb/A.
Biobit HP WP (6.4% a.i.): 0.5-2 lb/A.
CryMax WDG (15% a.i.): 0.5-1.5 lb/A.
DiPel DF (10.3% a.i.): 0.25-1 lb/A.
XenTari WDG (10.3% a.i.): 0.5-2 lb/A.

Bifenthrin (21 days-PHI)
For flea beetles.
Brigade 2EC: 2.1-6.4 fl oz/A.

Carbaryl (7 days-PHI)
For flea beetles, Colorado potato beetle, leafhoppers, cutworms, European corn borer, tarnished plant bug.
Carbaryl 4L; Sevin 4F; Sevin XLR Plus (4EC): 0.5-1 qt/A for flea beetles, leafhoppers; 1-2 qt/A for potato beetle, European corn borer, cutworm.
Sevin 80S: 0.62-1.25 lb/A for flea beetles, leafhoppers; 1.5-2.5 lb/A for potato beetle, European corn borer, cutworm.
Sevin 50WP: 1-2 lb/A for flea beetles, potato beetle, leafhoppers; 4 lb/A for cutworm; 2-4 lb/A for European corn borer.
Carbaryl 90DF: 0.6-1.1 lb/A for beetles, leafhopper; 1.1-2.2 lb/A for worms.

Carbofuran (14 days-PHI)
For flea beetles, Colorado potato beetle, leafhoppers, European corn borer.
Furadan 4F: 1-2 pt/A.

Clothianidin (14 days-PHI)
For Colorado potato beetle, aphids, leafhoppers.
Clutch 50WDG: 1-1.5 oz/A. Limit 3 applications per year.

Cryolite (0 days-PHI)
For Colorado potato beetle.
Kryocide (96% a.i.), Prokil Cryolite 96 (96% a.i.): 10-12 lb/A.
Limit 96 lb/A per season.

Cyfluthrin (0 days-PHI)
Baythroid 2E: 0.8-1.6 fl oz/A for cutworms and potato leafhopper; 1.6-2.8 fl oz/A for Colorado potato beetle, corn borer, flea beetles, plant bugs, looper. Limit 6 applications per year or 16.8 oz/A per year.

Deltamethrin (3 days-PHI)
Decis 1.5EC, Delta Gold 1.5EC: 1.0-2.4 fl oz/A for cutworms. 1.5-2.4 fl oz/A for armyworms, Colorado potato beetle, European corn borer, flea beetles, leafhoppers. Limit 12.0 fl oz/A per season. Allow 3 days between applications.

Dimethoate (0 days-PHI)
For leafhoppers, aphids.
Dimate 4EC; Dimethoate 400 (4EC): 0.5-1 pt/A.
Dimethoate 2.67EC: 0.75-1.5 pt/A.

Dinotefuran (7 days-PHI)
For Colorado potato beetle, flea beetle, aphids, leafhopper.
Venom 70SG: 1.5 oz/A. Limit 4.5 oz/A per season.

Disulfoton (30 days-PHI)
Foliar application for aphids only.
Di-Syston 8EC: 6-16 oz/A.

Endosulfan (1 day-PHI)
For flea beetles, Colorado potato beetle, leafhoppers, aphids, European corn borer, tarnished plant bug, tuberworm.
Thionex 3EC; Endosulfan 3EC: 0.7-1.3 qt/A.
Thionex 50WP: 1-2 lb/A.

Esfenvalerate (7 days-PHI)
For flea beetles, Colorado potato beetle, leafhoppers, aphids, cutworms, European corn borer, tarnished plant bug, tuberworm.
Asana XL 0.66EC, Adjourn 0.66EC: 2.9-5.8 oz/A for tuberworm; 5.8-9.6 oz/A for other pests.

Flonicamid (7 days-PHI)
For aphids, plant bugs.
Beleaf 50SG: 1.2-2.8 oz/A. Limit 3 applications per year.

Imidacloprid (7 days-PHI)
For Colorado potato beetle, aphids, leafhopper.
Provado 1.6F, Pasada 1.6F: 3.75 fl oz/A. Limit 15 fl oz/A per year. Do not use if Admire applied at planting.

Note: When applied as a foliar spray, imidacloprid has the advantage of requiring much lower rates to get the same control as from the in-furrow treatment. It has only localized systemic action, which means that the chemical moves across the leaf but will not redistribute to new growth. Two applications approximately 10-14 days apart may be needed to control an entire generation of beetles, and thorough coverage is a must as with any foliar spray. Because it has a much shorter residual period than the in-furrow treatment, resistance is expected to develop more slowly when foliar applications are used.

Imidacloprid + cyfluthrin (7 days-PHI).
For Colorado potato beetle, cutworm, European corn borer, flea beetle, leafhopper, tuberworm, tarnished plant bug.
Leverage 2.7 SE: 3.0-3.75 fl oz/A.

Indoxacarb (7 days-PHI).
For European corn borer, Colorado potato beetle larvae, cabbage looper, potato tuberworm.
Avaunt 30WG: 2.5-6.0 oz/A.

Malathion (0 days-PHI).
For leafhoppers, aphids.
Malathion 5EC: 1-2 pt/A.
Malathion 8EC: 1-3 pt/A.

Methamidophos (14 days-PHI)
For flea beetles, Colorado potato beetle, leafhoppers, aphids, cutworms, European corn borer, tarnished plant bug, tuberworm.
Monitor 4EC: 1.5-2 pt/A.

Methomyl (6 days-PHI)
For flea beetles, leafhoppers, aphids, cutworms, fall armyworm, tuberworm.
Limit 10 applications/crop.
Lannate 90SP: 0.5 lb/A for flea beetles, variegated cutworm, fall armyworm; 0.5-1 lb/A for leafhoppers, aphids, tuberworm.
Lannate LV (2.4WSL): 1.5 pt/A for flea beetles, variegated cutworm; 1.5-3 pt/A for leafhoppers, aphids, fall armyworm, tuberworm.

Methyl parathion (5 days-PHI)
For flea beetles, leafhoppers, aphids, cutworm, European corn borer, Colorado potato beetle, grasshoppers, plant bugs.
Penncap-M (2F, encapsulated): 2-4 pt/A for flea beetles, leafhoppers, cutworm, plant bug, and European corn borer; 2-6 pt/A for potato beetle.

Novaluron (14 days-PHI)
For Colorado potato beetle larvae, European corn borer.
Rimon 0.83EC: 9-12 fl oz/A. Limit 2 applications per year.

Oxamyl (7 days-PHI)
For flea beetles, Colorado potato beetle, leafhoppers, aphids, tarnished plant bug.
Vydate 2SL: 2-4 pt/A for flea beetles, leafhoppers, aphids; 1-4 pt/A for potato beetle.

Permethrin (14 days-PHI)
For flea beetles, Colorado potato beetle, leafhoppers, cutworms, European corn borer, tarnished plant bug, tuberworm.
Pounce 3.2EC, Arctic 3.2EC, Permethrin 3.2EC: 4-8 oz/A.
Ambush, Pounce 25WP: 6.4-12.8 oz/A for cutworms, European corn borer; 3.2-12.8 oz/A for beetles, leafhoppers, tuberworm.

Phosmet (7 days-PHI)
For flea beetles, Colorado potato beetle, leafhoppers.
Imidan 70WP: 1.3 lb/A. Limit 6.7 lb/A per year.

Pymetrozine (14 days-PHI)
Fulfill 50 WDG: 2.75 oz/A for aphids. Limit 5.5 oz/A per season.

Rotenone (0 days-PHI)
For Colorado potato beetle, flea beetles.
Bonide's Rotenone 5%: 3.2 oz/gal of water.

Soap (potassium salts of fatty acids) (0 days-PHI)
For aphids, leafhoppers.
M-Pede: 1 gal/A in 50 gal water per acre.
Do not use if temperature is above 90 degrees F.

Spinetoram (7 days-PHI)
For Colorado potato beetle, European corn borer.
Radiant 1SC: 6-8 fl oz/A. Limit 4 applications per year.

Spinosad (7 days-PHI)
For Colorado potato beetle, European corn borer.
SpinTor 2SC: 3-6 oz/A. Limit 21 oz/A per year. Apply when eggs are hatching. Use 3-4 oz/A for small larvae, or 5-6 oz/A for large larvae.
Entrust (80WP): 1-3 oz/A.

Spiromesifen (7 days-PHI)
For two-spotted spider mite, whiteflies, psyllid.
Oberon 2SC: 8.0-16.0 fl oz/A. Limit 2 applications per crop season.

Thiamethoxam (14 days-PHI)
For Colorado potato beetle, potato leafhopper, aphids.
Actara 25WDG: 1.5-3 oz/A. Limit 6 oz/A per season.

Zeta-cypermethrin (1 day-PHI)
For flea beetles, Colorado potato beetle, potato leafhopper, European corn borer.
Mustang Max 0.8EC: 1.28-4 fl oz/A.
Mustang 1.5EW: 1.4-4.3 fl oz/A.

Weed Control

Preplant Incorporated

EPTC: Preplant incorporated EPTC controls annual grasses, certain broadleaf weeds, and suppresses quackgrass and yellow nutsedge.

Eptam 7 E, Genep 7 E: 4.5- 6.8 pt/A preplant incorporated. Use the 6.8 pt/A rate only where nutsedge is a problem.

Preemergence

Linuron: Controls seedling broadleaf weeds and grasses. Must be preemergence to potatoes. Apply just prior to emergence of potatoes. Do not disturb soil until new flush of weeds appear.

Drexel Linuron 4L, Linex 4L: 1.5-4 pt/A.

Drexel Linuron DF, **Linex 50DF, Lorox DF**: 1.5-4 lb/A.

Dual Magnum: Controls germinating annual grasses, certain broadleaf weeds, and suppresses yellow nutsedge. Apply 1-2.0 pt/A Dual Magnum preemergence, at drag off, delayed preemergence or at layby for annual weed control. Follow a preemergence application of Dual Magnum with a delayed preemergence application of linuron or metribuzin.

Metribuzin: Controls small seedling broadleaf weeds up to 1 inch high. Biotypes of triazine resistant lambsquarters and pigweed occur in Ohio and will not be controlled. Do not harvest potatoes within 60 days after a planting—drag-off application or within 40 days after a layby application. Do not use on sand or muck soils. Applications to Atlantic, Shepody, Chip Bell, Bell Chip, and Centennial varieties may cause crop injury. Refer to the label for more specific details on rates, precautions and recropping intervals.

Sencor 75DF, Lexone 75DF: 0.6-1.0 lb/A preemergence to control annual weeds. Other formulations may be available.

Turbo 8 EC (metolachlor + metribuzin premix): 2 to 3.5 pt/A (60 days-PHI). Rate is dependent on soil texture and percentage of organic matter. Do not use on sand or muck soils. Applications to Atlantic, Shepody, Chip Bell, Bell Chip, and Centennial varieties may cause crop injury. Refer to the label for more specific details on rates, precautions and recropping intervals.

Matrix 25DF: For control of certain annual grasses and broadleaf weeds apply Matrix at 1-1.5 oz/A after hilling or drag-off. Matrix activation requires rainfall or irrigation within 3 days of application. Matrix can be tank-mixed with Lexone, Eptam, Prowl, Lorox, or Dual to improve the spectrum of weeds controlled.

Preemergence Tank Mixes

Dual Magnum at 1-2 pt/A, plus 1.0-2.5 lb/A, **Lorox 50 DF** just prior to emergence of crop for annual weed control.

Dual Magnum at 1-2 pt/A, plus 0.66-1.0 lb/A **Sencor 75DF** or **Lexone DF 75**; (other formulations available) just prior to emergence of crop for annual weed control.

Postemergence

EPTC: Apply postemergence after clean cultivation or at time of cultivation. Apply as directed spray. Potatoes should be 12-18 inches tall when this application is made. Do not apply more than 6 lb a.i./A in any one crop season. Incorporation is necessary for activity.

Eptam 7 E, **Genep 7 E:** 4.5 pt/A.

Metribuzin: For postemergent control of annual and certain perennial grasses. Apply postemergence to control annual weeds up to 1 inch tall. An herbicide of a different chemical family must be used to control triazine resistant biotypes. Do not apply after 3 consecutive cool, cloudy days. Do not spray during the 12-15 inch stage of the crop to avoid injury. Postemergence application is not recommended on red-skinned or early white-skinned varieties. Consult the label for sensitive varieties.

Sencor 4: 1-2 pt/A.
Sencor 75DF, Lexone 75DF, **Solupak DF**: 0.66-1.33 lb/A.

Matrix 25DF: Alone Matrix controls several annual grasses and broadleaf weeds, and suppresses quackgrass, Canada thistle, and yellow nutsedge. Apply Matrix at 1-1.5 oz/A to actively growing weeds less than 1 inch high. Include a non-ionic surfactant at 1-2 pt/100 gallons of water. Perennial weeds may require a second application of Matrix 14 to 28 days after the initial application to control late emerging shoots. Use no more than 2.5 oz/A of Matrix per season. Rainfall or irrigation within 5 days of application is necessary to provide residual control of germinating annual weeds. Postemergence applications of Matrix can be tank-mixed with certain fungicides, and with Lexone or Eptam. Temporary crop chlorosis may occur when crop stress due to environmental conditions occurs after application.

Poast: Controls emerged annual and perennial grasses. Apply 1-1.5 pt/A Poast. Do not exceed 5 pt/A/season. Add 1 qt/A nonphytotoxic oil concentrate. Rate is dependent on grass species and stage of development. UAN or Ammonium sulfate may be added to improve control of quackgrass and other weeds (30 days-PHI).

Select: Controls emerged annual and perennial grasses. Apply 8-16 fl oz/A (30 days-PHI). Do not exceed 32 fl oz/A/season. Add a crop oil concentrate at 1 qt/A on a volume basis (v/v). Liquid fertilizer or ammonium sulfate may be added, in addition to crop oil concentrate to improve control of quackgrass, johnsongrass and volunteer corn.

Vine Kill

Diquat: 1 pt/A applied to mature vines. Make a second application within 5 days if vines are thick. For Russet Burbanks, use 2 pt/A in the first application, 1 pt/A in a second application. Include a non-ionic surfactant at 2 pt/100 gallons (7 days-PHI).

Desicate II: 3-4 pt/A in 5-40 gallons of water. Use the high rate on lush, thick vines. Add ammonium sulfate or adjuvant to improve kill (10 days-PHI).

Gramoxone Extra: 0.8-1.5 pt/A in a minimum of 20 gallons of water to mature vines. Use 1.5 pt/A for a quicker kill. Use 2 applications, 5 days apart for thick vines. Do not use for potatoes grown for seed or storage (3 days-PHI).

Rely: 3.0 pt/A in sufficient water to ensure thorough coverage of potato vines (20-100 gal/A). Rely provides dessication of the potato plant within two to three weeks of application. Varieties with heavy or dense vines may require an application of another dessicant product to complete vine dessication. Do not use for potatoes grown for seed. Do not plant cereal grains until 70 days or more after use of Rely (9 days-PHI).