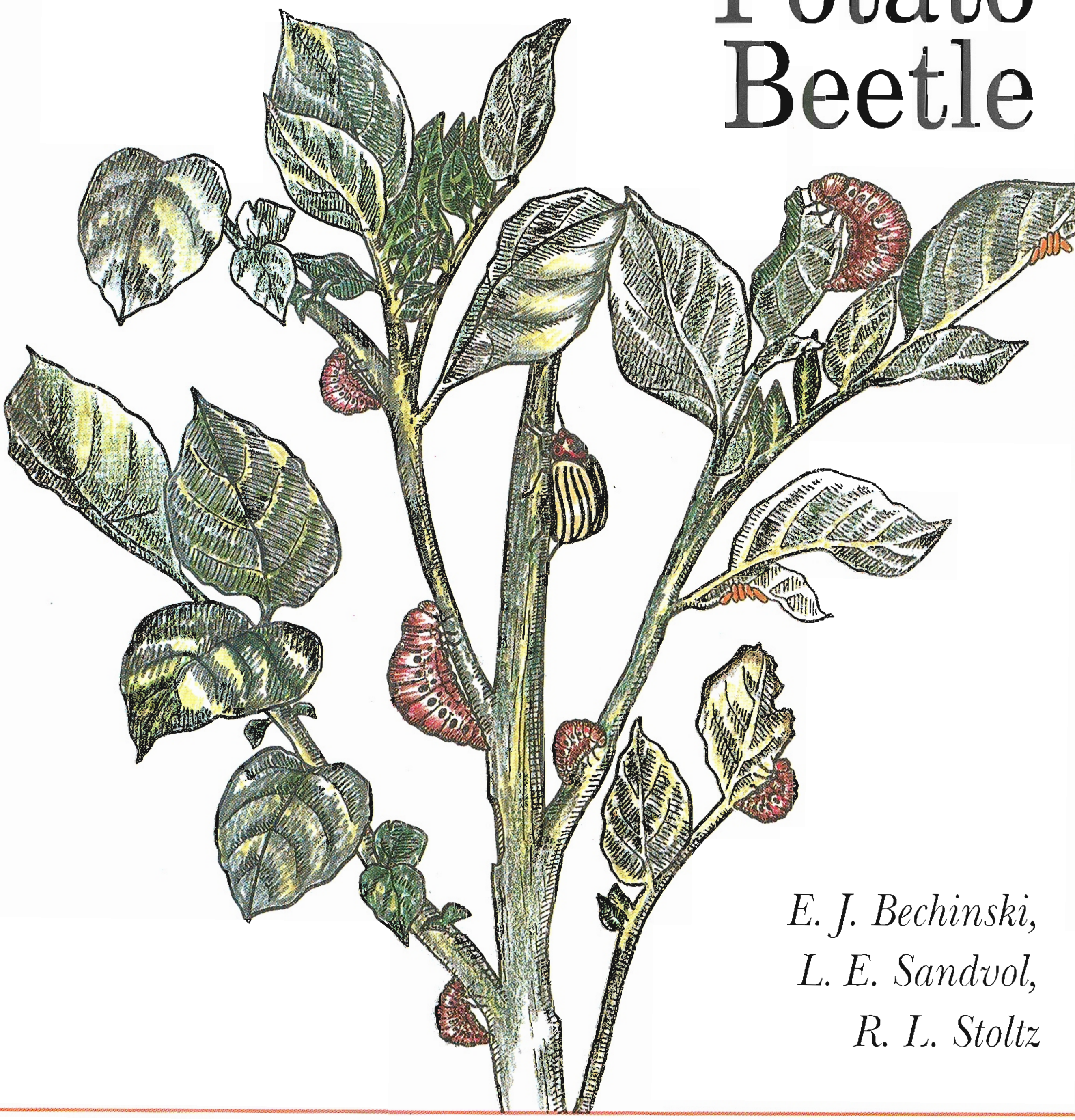
Integrated Pest Management Guide to

Colorado Potato Beetle



E. J. Bechinski,
L. E. Sandvol,
R. L. Stoltz

University of Idaho
College of Agriculture
Cooperative Extension System

EXT 757

Table of Contents

Figures and Tables

The Authors—Edward J. Bechinski, Extension IPM coordinator, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow; Larry E. Sandvol, Extension entomologist and Superintendent, Aberdeen Research and Extension Center; Robert L. Stoltz, Extension entomologist, Twin Falls Research and Extension Center.

Photo credit: *Photo on page 11 courtesy of Cornell University Cooperative Extension*

Colorado Potato Beetle

Colorado potato beetle, Leptinotarsa decemlineata, *is native to the western plains states. It was first detected in Idaho at Lewis and Nez Perce counties during 1905. Eradication programs kept its spread in check until the 1930s when extensive outbreaks permanently established populations in southern Idaho. Colorado potato beetle now occurs statewide.*

This publication describes how to design an integrated pest management (IPM) program for the Colorado potato beetle. An IPM program begins by identifying how weak links in the life cycle can be turned against the pest. Integrated pest management combines biological and cultural controls with field scouting, thresholds, and wise insecticide use. Because IPM uses pesticides only when needed, IPM farmers can increase profits while protecting the environment. IPM also is the best defense against pests developing insecticide resistance.

Fig. 1a. *Adult beetles have 10 black stripes on their yellowish-brown wing covers.*

Fig. 1b. *Humpbacked, reddish larvae have two rows of black spots along each side of their body.*

Identification

Adults are hard-bodied, oval-shaped beetles about 3/8-inch long and 1/4-inch wide. They are yellowish-brown with 10 thin black stripes on the wing covers and black spots on the head (fig. 1a). Eggs are yellow to light orange, oblong, and about 1/16-inch long. Beetles lay eggs in groups of 10 to 30 in orderly, perpendicular rows on the undersides of leaves. Newly hatched larvae are sluglike in appearance, with glistening black heads and feet and a cherry red body. As larvae grow, their head and legs remain black, but their body color changes to a yellowish-red or orange with two rows of black spots along each side (fig. 1b).

Life Cycle

Adults overwinter 4- to 10-inches deep in the soil of the previous year's potato fields. Beetles emerge just before potato plants begin to grow. Adults cannot fly until a week after emergence, so they first colonize fields by walking from nearby overwintering sites. Colonization by flying beetles begins 1 to 3 weeks later.

Adults must feed before they can reproduce. If potato plants are not available, beetles feed on **nightshade, ground cherry, henbane, tomato, eggplant,** and other members of the **nightshade** family. Adults will fly several miles if they do not find host plants where they overwintered. Heavy infestations often develop on volunteer potato plants, which emerge earlier than commercial potatoes. In areas where more than one generation occurs, beetles that develop on volunteers can start infestations in nearby commercial fields.

Adults lay 300 to 500 eggs over a 4-week period at scattered locations across potato fields. Beetles readily lay eggs on **hairy nightshade** and **black nightshade**, but larvae die after eating **black nightshade**. Eggs hatch in about 1 week. Larvae develop through four growth stages in 2 to 3 weeks. Mature larvae drop to the ground and burrow into the soil where they pupate within an earthen cell. They complete development to the adult stage in 5 to 10 days.

Summer adults may emerge immediately or they may remain in the soil and overwinter. Daylength (hours of sunlight) determines if beetles start another generation. Summer beetles that emerge before the fourth week in July lay eggs and begin a new generation. Later emerging beetles feed for a while, then burrow back into the soil and overwinter without reproducing until the following spring. Cool temperatures and maturing foliage can advance this date. Most overwintering beetles spend one winter in the soil, but some do not emerge for 2 or more years.

Two complete generations and a partial third usually occur in southwestern Idaho. Southeastern Idaho has one complete and a partial second generation. The rest of the state has two or fewer generations per year.

Generations overlap and often are difficult to distinguish. One way to distinguish newly emerged adults from survivors of the previous generation is to examine their hind wings. Newly emerged beetles have clear hind wings, while older beetles have smoky, orange-red hindwings.

Damage

Both adults and larvae feed on potato leaves and stems. Larvae are more damaging because they occur in higher numbers and feed on the terminal growth. Fourth stage larvae eat three times more foliage than stages one, two, and three combined. Although damage is highly visible, potatoes tolerate light to moderate leaf feeding without any economic loss.

Potato plants are most sensitive to defoliation at two times: when shoots first emerge and during tuber bulking (from row closure through full flower bloom). During vegetative stages, potato plants can recover from beetle damage. Defoliation during tuber bulking permanently reduces crop growth. After blooms fall and lower leaves begin to yellow, only extreme feeding by heavy infestations decreases potato yield.

Integrated Pest Management Methods

Field Scouting and Thresholds

Scout each field weekly as soon as potato plants emerge. At the beginning of the season, examine **nightshade** or volunteer potato plants along field margins. Adults or eggs on these alternate hosts indicate that you should begin more intensive scouting in commercial fields.

Inspect 100 linear feet of row for every 30 to 40 acres of field size (table 1). Do this by visually examining 10 feet of row at 10 different, random sites. Never inspect fewer than 10 sites, regardless of field size. Do not deliberately choose a particular section of row. One way to sample randomly is to walk a zig-zag path across the field, keeping your eyes fixed on the horizon. Then, without looking, stop and make your inspection.

Spread out your samples across the entire field (fig. 2). This insures that samples represent actual infestation levels. Walk a different path every week; do not inspect the same plants week after week.

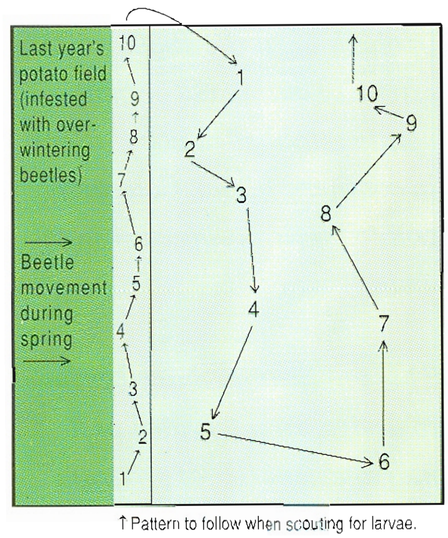


Fig. 2. Scouting pattern for fields up to 30 or 40 acres. Each number marks one 10-foot length of row to be inspected for beetle larvae. Walk a different zig-zag path every week. Infestations may be heaviest along field edges; you only may have to spray the borders, so inspect them separately. Divide larger fields into 30 or 40 acre blocks and inspect 100 feet of row (10 random 10-foot sections) in each block.

Table 1. Recommended numbers of samples when scouting fields for Colorado potato beetle larvae.

Field size	Samples needed *
up to 30 or 40 acres	100 row feet
up to 60 or 80 acres	200 row feet
up to 90 or 120 acres	300 row feet
120 acres or more	400 row feet

* Divide each 100 feet into 10 randomly located 10-foot sections.

Table 2. Economic thresholds for Colorado potato beetle.

Crop value	Control costs		
$/cwt	$5/acre	$10/acre	$15/acre
2	2-4*	4-9	5-14
4	2	2-4	3-7
6	2	1-3	2-4
8	1	1-2	1-3

*Values are numbers of larval-infested plants per 100 feet of row. Do not apply insecticides unless the average infestation level in your field is greater than these values.

Infestations often begin at field edges next to last year's potato fields, or near the nonirrigated corners of center pivot fields. Scout field edges separately from the rest of the field; you may have to spray only these areas.

Overwintering adults seldom cause serious defoliation on newly emerging plants. Consider control only if beetles are actively feeding and defoliation approaches 30 percent.

Inspect each 10-foot row section for Colorado potato beetle larvae. Record the number of plants in each 10-foot sample with at least one larval colony (fig. 3). Do not count numbers of larvae present, just the number of plants with larvae. Total the number of infested plants for each set of 10 samples. If you inspect more than one set of 10 samples, compute the average number of infested plants per 100 feet.

Use the economic thresholds in table 2 to decide if insecticides are needed. Thresholds depend on your control costs and expected crop value. For example, assume that it will cost you $15 per acre to purchase and apply an insecticide. If you expect to sell your crop for $4 per hundredweight (cwt), then the economic threshold is three to seven infested plants per 100 row-feet. Using the example in figure 3, the correct decision is to spray because the field count averages nine infested plants, which is greater than the economic threshold of three to seven infested plants.

Set 1		Set 2		Set 3		Set 4	
Sample number	# plants w/CPB larvae	Sample number	# plants w/CPB larvae	Sample number	# plants w/CPB larvae	Sample number	# plants w/CPB larvae
1	1	11	0	21		31	
2	2	12	0	22		32	
3	2	13	0	23		33	
4	2	14	1	24		34	
5	0	15	1	25		35	
6	0	16	2	26		36	
7	0	17	1	27		37	
8	1	18	0	28		38	
9	2	19	0	29		39	
10	1	20	2	30		40	
Total/100 ft	11	Total/100 ft	7	Total/100 ft		Total/100 ft	

Grand total (all sets)	÷	Number of sets examined	=	Field average per 100 ft
18	÷	2	=	9

Fig. 3. Use a data sheet like this to record the number of larval-infested plants in each of 10 different 10-foot lengths of row. Then determine the number of infested plants per 100 feet of row by adding up each set of 10 samples. Finally, calculate the average number of infested plants per 100 feet of row from across the entire field.

Table 3. Adjusting thresholds to fit your situation.

Factor		Recommendation
a. Are predatory insects present?		
	yes, present:	use higher threshold value
	no; unsure:	use lower threshold value
b. What is the stage of plant growth?		
	before row closing:	use lower threshold (decrease lower value for plants < 6 inches tall)
	from row closing through full bloom:	use higher threshold value
	after full bloom:	raise (increase) higher threshold
c. What is the predominant stage of larvae?		
	mostly small to medium:	use lower threshold
	mostly large larvae:	use higher threshold
d. Was a systemic insecticide used at planting for aphid control?	yes:	use higher threshold
	no:	use lower threshold
e. Are plants stressed by other pests (early blight, weeds)?	yes:	use lower threshold

When table 2 gives a range of thresholds, you can fine-tune the values to fit your situation by considering several factors. Thresholds in table 2 assume that larval infestations started from one egg mass per plant, resulting in 10 to 30 larvae per infested plant. If you notice during your inspections there are clearly fewer than 10 larvae per infested plant, use the higher threshold if table 2 lists a range of values. Conversely, if you see there are obviously more than 30 larvae per infested plant, use the smaller threshold. Also consider the factors in table 3.

Biological Controls—Native Predators, Parasites, & Diseases

Bigeyed bugs, damsel bugs, green lacewings, ladybird beetles, and **pirate bugs** feed on the eggs and small larvae of the Colorado potato beetle. The **two-spotted collops beetle**, *Collops bipunctatus*, is an effective egg predator.

Fig. 4. Two-spotted collops beetle.

The **twospotted stink bug**, *Perillus bioculatus*, feeds almost exclusively on Colorado potato beetles. It attacks larvae as well as eggs and adults and can be purchased for field releases. An important parasite is the **tachinid fly**, *Myiopharus doryphorae*, which attacks second through fourth stage larvae. A soil-borne fungus, *Beauveria bassiana*, forms a dense chalky mold that kills pupal and adult Colorado potato beetle and other insects in the soil.

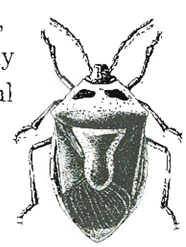


Fig. 5. Twospotted stink bug.

Extensive insecticide spraying limits the buildup of beneficial predators and parasites. Except for *Bacillus thuringiensis* microbial insecticides, the foliar insecticides used for beetles as well as aphids, loopers, and other potato insects are highly lethal to predatory and parasitic insects.

When using foliar insecticides, you can reduce harm to natural enemies by decreasing the number of applications. When pest infestations are spotty (such as along field borders), spot spray rather than treat the entire field. The inactive life stages (eggs and pupae) of beneficials tolerate insecticides better than the active immature or adult stages. If possible, time sprays to reduce exposure during these susceptible stages. Fungicides for blight control can interfere with the beneficial fungus disease, *Beauveria bassiana*. Mancozeb (Manzate) and metiram (Polyram) fungicides kill Beauveria but chlorothalonil (Bravo) and metalaxyl (Ridomil) fungicides do not.

Many predatory and parasitic insects require nectar or pollen to reproduce. Preliminary data show that fence row border plantings of **alfalfa, buckwheat, clover, mint, vetch**, or other small-flowered plants can increase populations of natural enemies. Border plantings may also provide refuges that allow beneficials to escape insecticide sprays and later recolonize fields. Beneficial insects will naturally move into the crop after border plants bloom, or you can force their movement by mowing. Border plants can also harbor pest species. **Lygus bugs** and **spider mites** are the pests most likely to reproduce in legume border plantings and move into potato fields. Buildup of **pea aphids** and **alfalfa weevils** may threaten neighboring hay fields.

Biological Controls—Mass Releases

You can supplement native beneficials with periodic releases of insects purchased from commercial insectaries (table 4). Most are marketed for backyard gardeners and are too expensive for commercial use. None have been tested in Idaho for Colorado potato beetle control. Release rates often are set by the suppliers themselves rather than from research studies. If you wish to make trial releases, target second generation eggs and larvae. Low temperatures and small egg and larval populations make biological control more difficult during the first generation.

One promising species is the **spined soldier bug**, *Podisus maculiventris,* a predatory stinkbug that feeds on eggs, larvae, and adult Colorado potato beetles. Spined soldier bug also attacks **loopers, armyworms**, and other leaf-feeding caterpillars. It is native to the eastern United States and should be able to survive Idaho winters. A synthetic sex attractant (Rescue! Soldier Bug Attractor, Sterling International, Inc., P.O. Box 220, Liberty Lake, Washington, 99019) can be used to keep soldier bugs at release sites. The attractor consists of a 6-inch tall plastic cone, and is intended primarily for home gardens and backyard orchards.

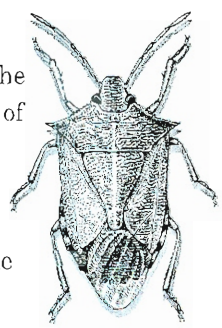


Fig. 6. Spined soldier bug.

Another promising species is the egg parasite, *Edovum puttleri*, a 1/16-inch long stingless wasp that lays its egg within Colorado potato beetle eggs. Parasite eggs hatch into grubs that internally consume the beetle egg. Adult wasps also feed on beetle eggs. Unlike the **spined soldier bug**, *Edovum* is a tropical species that cannot survive Idaho winters. Periodic releases would be needed each year. Control has been best in other parts of the United States when patches of aphid-infested plants are nearby, because adult wasps feed on the honeydew aphids produce.

Biological Controls—Bt Microbial Insecticides

Bt insecticides contain toxins produced by a bacterium, *Bacillus thuringiensis*, or Bt for short. The *san diego or tenebrionis* strains of Bt produce toxins that kill only Colorado potato beetle larvae. Commercial products include M-One and M-Trak (Mycogen Corp.) and Foil (Ecogen Corp.). These Bt insecticides are harmless to beneficial predators and parasites, bees, wildlife, people, pets, and other nontarget organisms. They break down rapidly in the environment and do not contaminate water and soil.

Precise timing is the most critical factor when using Bt insecticides. Application typically kills more than 95 percent of first and second stage Colorado potato beetle larvae, but only 50 percent of third stage and 20 percent of fourth stage larvae. Bt does not kill adult beetles. Apply Bt microbials after about 30 percent of eggs hatch but before larvae grow more than 1/8-inch long. Use conventional chemical insecticides if you have mixed infestations of small and large larvae.

Table 4. Commercially available biocontrol agents for Colorado potato beetle.

Common and scientific name	Stage attacked	Native to Idaho?	*Sources (see table 5)
ladybird beetles *Hippodamia convergens*	*eggs*	*yes*	*1,4,5,7,8,9,10,11,12,14,15,16,17*
green lacewing *Chrysoperla carnea*	*eggs and small larvae*	*yes*	*2,3,5,7,8,9,11,12,15,16,17*
minute pirate bug *Orius tristicolor* *Orius indidiosus*	*eggs and small larvae*	 *yes* *no*	 *1,3,4,9,10,11,13,14,15,16* *6,13*
spined soldier bug *Podisus maculiventris*	*eggs, larvae (all sizes) and adults*	*no*	*1,14*
twospotted stink bug *Perillus bioculatus*	*eggs, larvae, and adults*	*yes*	*14*
egg parasite (wasp) *Edovum puttleri*	*eggs*	*no*	*14*

Table 5. Source list of commercially available biocontrol agents.

1. ARBICO, Inc.
   P.O. Box 4247 CRB
   Tucson, AZ 85738
   (800) 827-2847, (602) 825-9785
   FAX (602) 825-2038

2. Beneficial Insectary
   14751 Oak Run Road
   Oak Run, CA 96069
   (916) 472-3715
   FAX (916) 472-3523

3. BO-BIOTROL, Inc.
   2404 East Amity Avenue
   Nampa, ID 83686
   (208) 467-9663

4. Bozeman Bio-Tech
   P.O. Box 3146
   Bozeman, MT 59772
   (800) 289-6656, (406) 587-5891

5. Buena Biosystems
   P.O. Box 4008
   Ventura, CA 93007
   (805) 525-2525
   FAX (805) 525-6058

6. Bunting Biological North America
   P.O. Box 2430
   Oxnard, CA 93034-2430
   (805) 986-8265
   FAX (805) 986-8267

7. Harmony Farm Supply
   3244 Gravenstein Hwy. No.
   Sebastopol, CA 95472
   (707) 823-9125
   FAX (707) 823-1734

8. Hydro-Gardens, Inc.
   P.O. Box 25845
   Colorado Springs, CO 80936
   (800) 634-6362, (719) 495-2266
   FAX (719) 531-0506

9. IFM
   333 Ohme Gardens Road
   Wenatchee, WA 98801
   (509) 662-3179

10. M & R Durango, Inc.
    6565 Hwy 172
    Ignacio, CO 81137
    (800) 526-4075, (303) 259-3521
    FAX (303) 259-3857

11. Nature's Control
    P.O. Box 35
    Medford, OR 97501
    (503) 899-8318
    FAX (503) 899-9121

12. Peaceful Valley Farm Supply
    P.O. Box 2209
    Grass Valley, CA 95945
    (916) 272-GROW
    FAX (916) 272-4794

13. Plant Sciences, Inc.
    514 Calabasas Road
    Watsonville, CA 95076
    (408) 728-7771
    FAX (408) 728-4967

14. Praxis
    P.O. Box 360
    Allegan, MI 49010
    (616) 673-2793
    FAX (616) 673-2793

15. Rincon-Vitova Insectaries, Inc.
    P.O. Box 1555
    Ventura, CA 93002
    (805) 643-5407
    FAX (805) 643-6267

16. TRI CAL Biosystems
    P.O. Box 1327
    Hollister, CA 95024-1327
    (408) 637-0195

17. Unique Insect Control
    5504 Sperry Drive
    Citrus Heights, CA 95621
    (916) 961-7945
    FAX (916) 967-7082

One simple way to time Bt sprays is to pick 10 potato leaves that each have a beetle egg mass. Place the leaves in a vented jar out of direct sunlight in an unheated porch or shop. Inspect egg masses daily. When 3 to 5 of the 10 egg masses hatch, apply Bt in your field. Alternatively, flag 10 egg masses on plants in the field and inspect them daily. Regardless of which approach you take, you still must scout fields to determine if infestations are greater than threshold levels.

All Bt insecticides are stomach poisons; they do not work unless larvae eat treated foliage. Spray plants thoroughly to insure that larvae ingest a lethal dose. Larvae stop feeding a few hours after eating treated foliage, but remain on plants and do not die for several days. Temperature also affects control; the warmer the temperature, the more treated foliage larvae consume. Apply Bt on days when temperatures will exceed 75 to 80°F for 6 to 8 hours. Results may be erratic if you spray when temperatures are less than 65°F.

Some people promote tank mixing Bt with feeding stimulants to increase larval feeding, but field tests have shown this is not necessary. Fungicides containing TPHT (Du-Ter, Super Tin) or copper (Kocide), however, have an antifeedant effect on Colorado potato beetle larvae. These fungicides can reduce control with Bt if larvae stop eating before consuming a lethal dose.

Control usually requires two or more applications because Bt insecticides have little residual activity. Bacteria do not infect other larvae when an infected host dies. First generation control requires a second application and sometimes a third at 5- to 7-day intervals. Second generation control during the heat of summer is more difficult because larvae quickly grow beyond susceptible stages. Scout fields every other day and shorten the spray interval to 3 or 4 days. Encapsulated formulations (M-Trak) extend residual activity from 2 to about 4 days.

Cultural Controls

Crop management practices can reduce beetle populations by delaying beetle colonization at the beginning of the season. This reduces the size of the first generation. It also delays the emergence of summer beetles so only a smaller partial second generation develops. Do not depend on cultural controls to work by themselves; they are most effective combined with biological and other controls.

Virtually all growers already rotate potato fields for nematode, weed, and disease control. Rotation is also effective against Colorado potato beetles because it increases the time and distance beetles must travel to find a host plant. Proximity to overwintering sites determines how early and how many beetles colonize commercial potato fields. When practical, isolate fields several hundred yards from previous year's fields.

Rotational crops also act as barriers to beetles emerging from overwintering sites. Wheat or barley rotations following potatoes are especially effective. Rogue-out volunteer potato plants and **nightshade** in rotational crops that follow potatoes. These plants are an important food source for emerging beetles.

In areas where a second generation develops, delaying planting by 7- to 14-days may cause summer beetles to emerge too late to start a new generation. However, delayed planting also reduces crop yield. Yield decreases may outweigh any benefits of beetle control. You can reduce the second generation population by planting early varieties that mature before the larvae completely develop. Harvest vine-killing practices that destroy all foliage also reduce second generation numbers.

During the growing season, determine crop nitrogen needs by petiole analysis. Overfertilization with nitrogen increases larval survival by improving the nutritional quality of the foliage.

Two other cultural methods used experimentally in the eastern United States are *trap crops* and *mulches*. We do not yet have enough information to know if either works in Idaho. Trap crops involve planting a few rows of potatoes around the edge of commercial fields several weeks before the main crop. The early-emerging trap crop concentrates migrating beetles where they can be killed with insecticides before infesting the main crop. Mulching with straw 2- to 4-inches deep between the rows physically prevents overwintering beetles from walking into fields. Mulches also provide habitat for ground beetles, spiders, and other beneficial biological controls. Equipment for applying straw mulches as a soil erosion control is available commercially (Hobson Manufacturing, Inc., Ontario, Oregon, 97914; Morgan Manufacturing, Ontario, Oregon, 97914).

Resistant Varieties

There are no commercially available potato varieties resistant to the Colorado potato beetle. Cornell University, New York, has developed a beetle-resistant clone (NYL 235-4), but has yet to market it. Private industry is developing genetically engineered potato cultivars that produce the Bt toxin within their foliage. Several varieties showing great promise in tests conducted in Idaho may reach commercial markets during 1996.

Mechanical Controls

Growers in the eastern United States increasingly use *propane flamers* and *crop vacuums* for beetle control. Neither flamers nor vacuums have been used in Idaho, primarily because our infestations are much less severe and insecticides still are effective here. The following recommendations come from studies in Michigan and New York.

Growers use flamers at the beginning of the season to kill overwintering beetles as the beetles emerge and walk into fields. Flamers consist of propane burners (as used for weed control) mounted on a hydraulic boom in front of a tractor (fig. 7). Flaming over the top of plants kills 50 to 90 percent of adult beetles and reduces egg hatch 30 to 50 percent. Flamer operation at 4 to 6 mph minimizes plant injury; so does proper spacing of the burners. Although leaves turn brown along the edges, plants recover without loss of yield.

Flamers typically consist of two liquid burners per row operating at 25 pounds per square inch (psi) (fig. 8). Burners are arranged on opposite sides of the row, about 8 to 12 inches from row center and 6 to 10 inches above ground. Burners face forward at a 30° angle from the boom and point down toward the plants at a 45° angle. Flaming is effective on plants up to 8-inches tall. Taller

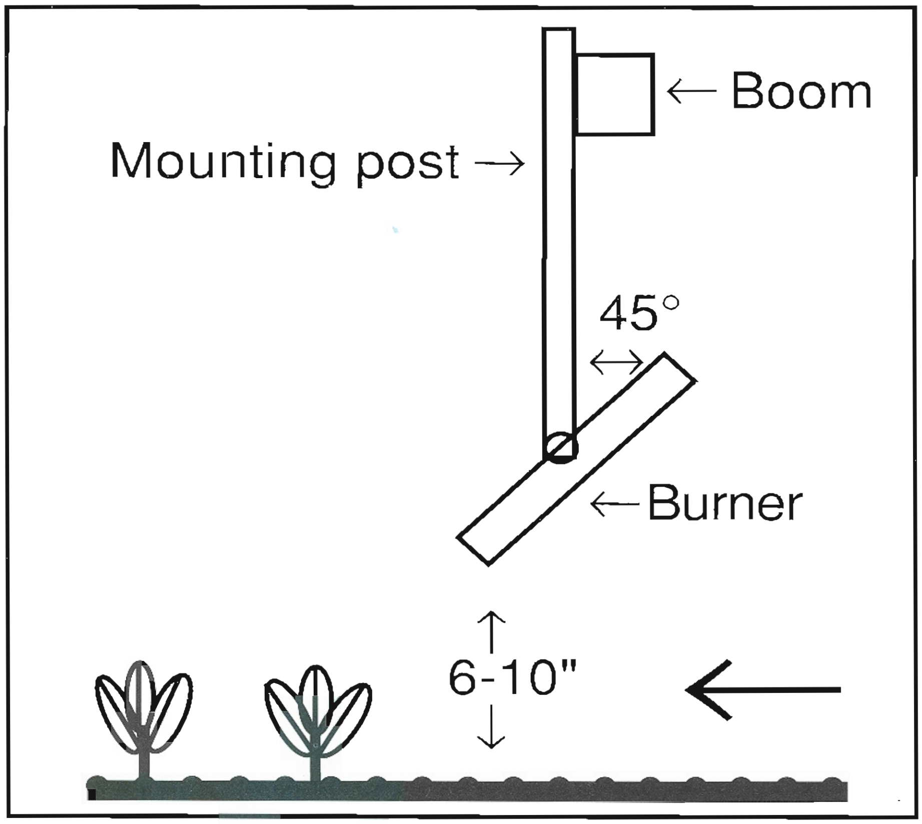


Fig. 8. Side view of a pair of propane flamers.

Fig. 7. Four-row propane flamer.

plants are more susceptible to heat damage and they shelter beetles from flames. Control is best on calm, sunny days when beetles are feeding at the top of plants. Flaming into winds greater than 15 mph reduces control.

Crop vacuums suck larvae and adults from plants with high speed fans. They remove nearly all newly hatched larvae and about 70 percent of larger larvae and adult beetles. Vacuuming also produces a sand-blasting effect that destroys most eggs. Except for fast-flying species, vacuuming also kills beneficial natural enemies. Vacuums work on larger plants than propane flamers, but like flamers, their effectiveness decreases under windy conditions.

Four- and six-row units are typical for both flamers and vacuums. This small size limits the acreage that can be covered and compacts the soil. Cost is another consideration. Only crop vacuums are sold commercially. Manufacturers include DACO Farm Supply (1902 High St., P.O. Box 7, Delano, California, 93216), IAP (P.O. Box 56, Phillips, Wisconsin, 54555), Sukup Manufacturing (Box 677, Sheffield, Iowa, 50475) and Thomas (P.O. Box 130, Centreville, New Brunswick, CANADA E0J 1H0). Flamer construction costs about $2,500 to $3,000, and operation costs about $5 to $7 per acre. Work with a LP (liquid propane) gas technician if you build a unit.

Trench trapping at field edges is another mechanical control that has been used only in the eastern United States. Plastic-lined trenches 1- to 2-feet deep and 6- to 24-inches wide trap beetles as they walk into fields from adjacent overwintering areas. The plastic-lined surface is too slippery for beetles to climb out and only a small percentage fly out. Beetles die in the trench from natural causes. Estimated cost is $40 per 1,000 linear feet. Populations of overwintering beetles in Idaho are too low to justify this expense.

Insecticides

Biological and cultural methods reduce but do not eliminate the need for insecticides. Consult your Extension agricultural agent about currently registered insecticides. Do not apply systemic insecticides at planting for Colorado potato beetle control. It is more cost effective and more environmentally sound to scout fields and apply foliar insecticides only when infestations exceed threshold levels. If **green peach aphids** are also present, select an insecticide that controls both.

Reducing insecticide use also slows down the development of insecticide resistance. Field studies of Colorado potato beetles in Idaho during 1992 showed that some resistance is occurring to synthetic pyrethroid and organophosphate insecticides. Susceptible beetles do still occur in the same area as resistant beetles. Interbreeding between them has kept resistance levels low compared to other parts of the country. Resistance has not yet been detected in Idaho to carbamate or chlorinated hydrocarbon insecticides. Some Idaho populations can tolerate many times the dosage of some carbamates that are lethal to beetles from other parts of the state. This means that the genetic potential exists for resistance to all four classes of insecticides.

You can extend the effective life of insecticides as follows:

1. Do not always use the same class of insecticide in the same field. Instead, rotate among the major classes (table 6). Keep written application records for each field. Take into account both granular systemics and foliar insecticides for wireworms, aphids, and loopers as well as for Colorado potato beetle. For example, if beetles show resistance to Imidan (an organophosphate), resistance might increase if you apply Thimet (another organophosphate) for wireworms and Monitor (also an organophosphate) for aphids.

2. Test adult beetles for resistance by using the kit developed by Dr. Tom Mowry, Parma Research & Extension Center, University of Idaho. This inexpensive, easy-to-use test kit quickly tells if beetles are resistant to carbamate, chlorinated hydrocarbon, organophosphate, or pyrethroid insecticides. Use the kit on spring adults to decide which classes will work best for you. Your local Extension agricultural agent can obtain kits for you.

3. Never spray on a fixed calendar schedule. Use insecticides only when infestations are greater than thresholds. When control is needed, spray at the maximum labelled rates. Spraying at less than the maximum labelled rates kills the susceptible beetles and leaves the resistant beetles. This increases the level of resistance.

Table 6. Classes of insecticides used in potato fields to control wireworms, aphids, Colorado potato beetle, or other insect pests.

BOTANICALS
rotenone

CARBAMATES
Lannate
Furadan
Sevin
Vydate

CHLORINATED HYDROCARBONS
methoxychlor
Thiodan

MICROBIALS
M-One
M-Trak
Foil

MINERALS
Kryocide

ORGANOPHOSPHATES
Cygon
Diazinon
Di-Syston
Guthion
Imidan
Malathion
Monitor
Phosdrin
Thimet

PYRETHROIDS
Ambush
Asana
Pounce

NOT ALL CAN BE USED FOR COLORADO POTATO BEETLE.
If you suspect that beetle resistance is developing to an insecticide from one class, switch to an insecticide from a different class.

Summary: IPM Checklist for Commercial Growers.

✓ Become familiar with the life cycle of the Colorado potato beetle; understand how alternative host plants, colonization by overwintering beetles, and seasonal generations determine the severity of infestations.

✓ Rotate potato fields; wheat or barley following potatoes is an effective rotation.

✓ Scout fields weekly; never apply insecticides unless infestations exceed economic thresholds.

✓ Learn how to identify native predators; preserve and increase populations of these beneficials by minimizing foliar insecticide use.

✓ Try to fit Bt microbials into your management plans; they are harmless to nontarget organisms and can be as effective as chemical insecticides.

✓ Do not rely solely on insecticides.

✓ Rotate classes of insecticides to avoid resistance.

Trade names—To simplify information, trade names have been used. No endorsement of named product is implied, nor is criticism implied of similar products not mentioned.
Groundwater—To protect groundwater, when there is a choice of pesticides, use the product least likely to leach.

To order these or other University of Idaho publications, write:

Agricultural Publications
Idaho Street
University of Idaho
Moscow, ID 83844-2240
or call: (208) 885-7982

PNW 343 Beneficial Organisms Associated with Pacific Northwest Crops ($1)
An eight-page bulletin that will help
you to identify common predatory and parasitic insects.

1993 Pacific Northwest Insect Control Handbook ($15)
Annually-revised insecticide recommendations.

University of Idaho Potato Handbook ($45)
Annually-revised collection of publications. Subscription price includes new titles through 1996.

Issued in furtherance of cooperative extension work in agriculture and home economics, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, LeRoy D. Luft, Director of Cooperative Extension System, University of Idaho, Moscow, Idaho 83844. The University of Idaho provides equal opportunity in education and employment on the basis of race, color, religion, national origin, gender, age, disability, or status as a Vietnam era veteran, as required by state and federal laws.

800, 2-94

$2.50