

PLANT DISEASE MANAGEMENT FOR COMMERCIAL VEGETABLE CROPS

Successful control of vegetable diseases requires an integrated program that includes the use of resistant varieties, crop rotation, balanced soil fertility, weed and insect control, and proper crop culture, as well as the proper selection, timing, and method of applying fungicides, bactericides, or nematicides. Economical control depends on establishing an overall disease-management system for the entire farm. Keeping careful records of the crops planted, the problems encountered, and the pesticides used is important.

Because many disease problems originate with seeds or transplants, growers should follow the seed-treatment recommendations given in this chapter and in *Report on Plant Diseases (RPD)*, no. 915, "Vegetable Seed Treatment" (ordering information is at the end of this chapter) or be sure to obtain planting material that is certified as disease free.

This chapter lists the registered fungicides and application intervals for various vegetable crops as approved by the Food and Drug Administration (FDA) and the U.S. Environmental Protection Agency (US EPA) as of September 1, 1999, to the best of our knowledge. Tables 1 and 2 give the number of days between the last application at the normal rate and harvest, as well as other restrictions to keep residues within the tolerances set by the FDA. Refer to current labels for information on rates, timing, and methods of application, as well as for information on follow-up crops and other restrictions.

The listing of a chemical as approved for use on a particular crop does not mean that University of Illinois Extension or the Office of Research recommends its use for that crop. Our specific recommendations for disease control are given in Table 3.

In some instances, a tolerance has been set, but a definite interval has not been established. The absence of an interval for a crop in the listings does not necessarily mean that the fungicide may not be used on that crop. To ensure that the crop produced does not exceed the tolerance, the use of the fungicide would require a restriction such as "Do not apply after first blooms appear" or "Do not apply after edible parts form." This information appears on the product label.

In a few cases, the interval and dosage have been established, but the allowable residue concentration has not been determined. Again, this does not mean that the fungicide may not be used on the crops for which the fungicide is labeled. It does mean, however, that until the tolerance is established, it must be considered as zero. These cases are reviewed each year, and some are canceled when the chemical manufacturer supplies the EPA with additional data.

Growers must follow a program of disease control ensuring that the vegetables produced do not contain excessive fungicide residues. Vegetables marketed with residues exceeding the FDA tolerances may be injurious to consumers, may be confiscated, and may subject the grower to legal action.

Growers have nothing to fear from the law so long as they use fungicides and other pesticides according to the current labels and only on the crops specified, in the amounts specified, and at the times specified. The prudent grower keeps a record of the products and trade names used, the percent of active ingredients, dilutions, rates of application per acre, and dates of application.

The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

FUNGICIDE APPLICATION

We recommend that the following practices be used when applying fungicides.

- Cover the foliage uniformly. *Ground application*—Apply 75 to 125 gallons per acre at 100 to 400 pounds per square inch of pressure. Lowering the volume, pressure, or both may provide adequate coverage; but high-volume, high-pressure applications provide ideal coverage. Make sure the sprayer is functioning properly. Check the nozzles for cleanliness and wear. Boom height, accuracy of pressure gauge, agitation, and calibration should also be checked. *Aerial application*—Apply recommended amounts of pesticide in 3 to 5 gallons of water per acre. Make sure nozzles are properly aligned and clean so that uniform application is achieved. Cover a swath no wider than is reasonable for the aircraft and boom being used. Spray only those fields that are suitable for aerial application. Avoid fields of irregular shape or topography, particularly if they are bounded by power lines, trees, or other obstructions.
- Whenever possible, spray when the air is still or when wind velocity is less than 10 mph.
- Avoid situations where pesticide drift may cause needless problems.
- When it is compatible with the product label, use a spray adjuvant (surfactant). Commonly available surfactants include Bio-Film, Kalo-Bio 88, and Regulaid (for systemic fungi-cides); DuPont Spreader-Sticker; Hopkins-Plyac; Miller—NuFilm P and NuFilm 17; Ortho—Chevron Spray Sticker, Chevron Spreader, and X-77 Spreader; and Rohm & Hass—Triton AG-98 B-1956, and CS-7. Spray adjuvants are most useful on cabbage, cauliflower, Brussels sprout, onions, and peppers.

SOIL FUMIGATION

Follow the manufacturer's directions exactly. Fumigants work best in light, loose soils that are free of trash, clods, and lumps. Avoid recontaminating treated soil. It is best to apply fumigants during the fall before planting. In general, the soil temperature must be at least 55° to 60°F at the 6-inch depth, with a time lapse of 21 to 28 days between treating and seeding. Some fumigants require gas-tight plastic covers. Many fumigants are restricted-use chemicals.

USING NEMATICIDES

Use nematicides only where soil analysis shows a nematode problem to be present. Follow soil sampling instructions in RPD no. 1100, "Collecting and Submitting Soil Samples for Nematode Analysis." Both no. 1100 and no. 915 (discussed earlier) are available from the Department of Crop Sciences, N-533 Turner Hall, 1102 South Goodwin Avenue, Urbana, IL 61801.

RECOMMENDED WEB RESOURCES

<http://www.aces.uiuc.edu/~ipm/news/fvnews.html>
For information on vegetable crops in Illinois, *Illinois Fruit & Vegetable News*, current and archived issues. Includes IPM links and "Ask an Expert" section. Published weekly during the summer.

<http://www.scisoc.org>
Information on plant diseases. Web site of the American Phytopathological Society. News features, reports, other public-access information, as well as subscription journals.

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Table 1. Limitations on days between application and harvest, and other restrictions on using fungicides on vegetables in Illinois

Crop	Benomyl ^a	Chlorothalonil ^b	Mancozeb ^c	Maneb ^d
Asparagus	...	...	A; root dip	...
Beans (dry, lima, snap)	14 (dry/snap) 28 (other succulent)	7 (snap only), B 14 (lima, dry), B	...	30 (dry only)
Beet, garden	...	...	...	...
Broccoli	...	7	...	7
Brussels sprout	7	7	...	7

Table 1. Limitations on days between application and harvest, and other restrictions on using fungicides on vegetables in Illinois (cont.)

Crop	Benomyl ^a	Chlorothalonil ^b	Mancozeb ^c	Maneb ^d
Cabbage	...	7	...	7
Cantaloupe (musk-melon, honeydew melon)	1	0	5	5
Carrot	4	0	...	...
Cauliflower	...	7	...	7
Celery	7	7	...	...
Chinese cabbage	7	7	...	10
Corn, sweet and pop	...	14, BE ^e	7, B	7, B
Cucumber	1	0	5	5
Eggplant	...	...	...	5
Endive, escarole	...	...	...	10
Fennel	...	...	14	...
Garlic	...	7	...	...
Kale	...	...	...	10
Kohlrabi	...	...	...	7
Leek	...	14	...	...
Lettuce	...	...	...	10
Mustard greens	...	...	...	...
Onion	...	7 (dry)	7, D, pb	7, D, pb
Parsley	...	...	...	...
Parsnip	...	10,B	...	...
Peas	...	...	...	...
Pepper	...	...	...	7
Potato, Irish	...	7	14, C	14, C
Pumpkin	1	0	...	5
Radish	...	...	...	...
Shallots	...	14	...	...
Spinach	...	...	...	...
Squash	1	0	5 (summer only)	5
Tomato	1	0	5	5
Turnip, rutabaga	...	...	...	...
Watermelon	1	0	5	5

Numbers indicate days between last application and harvest; 0 = up to harvest; ... = fungicide is not registered for use on that particular vegetable; A = postharvest application to ferns only or to young plantings that will not be harvested; B = do not feed treated tops or forage to livestock; C = do not use treated seed or seed pieces for feed or food; D = do not apply to exposed bulbs; E = Do not ensile treated corn or use as livestock forage; pb = plant-bed treatment; ph = postharvest spray or dip.

^aBenomyl is a systemic fungicide sold as Benlate. Do not apply Benlate alone; always use in combination with mancozeb or other labeled protective fungicides such as Captan, Bravo, Dyrene, or maneb. Do not mix with Mertect or Topsin-M.

^bChlorothalonil is a contact-protective fungicide sold as Bravo 500, Bravo Ultrex, Bravo Weather Stik, Bravo Zn, Terranil 6L, and Terranil 90DF. It is also sold in combination with mefenoxan as Ridomil Gold Bravo.

^cMancozeb is a contact-protective fungicide sold as Dithane F-45, Dithane M-45, Dithane DF, Manzate 200DF, and Penncozeb.

^dManeb is a contact-protective fungicide sold as Maneb 75DF, Maneb 80WP, and Manex.

^eDo not apply if the crop will be used for processing.

Table 2. Label information on fungicides and nematicides of less general use

Fungicide	Crops and use restrictions
Aldicarb (Temik 15G)	Beans (dry), sweet potato: for nematode control. Read and follow label directions.
Azoxystrobin (Quadris)	Curcubits: anthracnose, belly rot, downy mildew, gummy stem blight, leaf spots, powdery mildew; 1 day. ^a Read and follow label directions. Potato: early blight and late blight, 14 days. Read and follow label directions. Tomato: for anthracnose, black mold, Buckeye rot, early blight, powdery mildew, Septoria leaf spot, target spot, late blight; 7 days. ^a Read and follow label directions.
bordeaux mixture (many trade names)	Asparagus, beans, beet, broccoli, Brussels sprout, cabbage, carrot, casaba melon, celery, collard, crenshaw melon, cress, cucumber, eggplant, honeydew melon, horseradish, kale, muskmelon, mustard, pepper, Persian melon, potato, pumpkin, radish, rape, rutabaga, spinach, squash, tomato, turnip, watermelon. Read and follow label directions.
Captan (Captan 30-DD, Captan 400)	Beans (snap, dry, cowpeas), beet (garden), broccoli, Brussels sprout, cabbage, cantaloupe, cauliflower, corn (sweet), crucifers (collard, kale, mustard, radish, rape, turnips), cucumber, lentils, muskmelon, peas, pepper, pumpkin, spinach, squash, Swiss chard, watermelon: seed protectant. Read and follow label directions.
Copper fungicides^b copper sulfate (many)	Beans, cantaloupe, celery, cucumber, honeydew melon, muskmelon, pepper, Persian melon, potato, pumpkin, squash, tomato, watermelon. Read and follow label directions.
copper ammonium carbonate (Copper-Count N)	Beans, cabbage, cantaloupe, carrot, celery, curcubits, eggplant, honeydew melon, lettuce, onion, peas, pepper, potato, squash, tomato, watermelon. Read and follow label directions.
copper hydroxide (Kocide DF, Kocide 4.5 LF, Kocide 101, Kocide 2000)	Beans, broccoli, Brussels sprout, cabbage, cantaloupe, carrot, cauliflower, celery, cucumber, eggplant, lettuce, muskmelon, onion, pea, pepper, potato, pumpkin, squash, tomato, watermelon. Read and follow label directions.
copper oxychloride (many)	Beans, beet, broccoli, Brussels sprout, cabbage, cantaloupe, carrot, casaba melon, cauliflower, celery, crenshaw melon, cucumber, eggplant, honeydew melon, lettuce, muskmelon, onion, peas, Persian melon, potato, pumpkin, spinach, squash, tomato, watermelon. Read and follow label directions.
tribasic copper sulfate (many)	Read and follow label directions.

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
Ethoprop (Mocap)	Beans (snap and lima), cabbage , corn (sweet), cucumber , potato , sweet potato : for nematode control. Read and follow label directions.
Fenamiphos (Nemacur 15G)	Brussels sprout , cabbage , eggplant , garlic , okra , pepper (non-bell): for nematode control. Read and follow label directions.
Fludioxonil (Maxim 4FS)	Sweet corn : seed treatment for seedborne and soilborne fungi causing seed decay, damping-off, and seedling blights. Read and follow label directions.
(Maxim)	Potato : potato seed protectant. Read and follow label directions.
Fosetyl-AL (Aliette)	Broccoli , broccoli Raab , Brussels sprout , cabbage , Chinese broccoli , Chinese cabbage (Bok Choy and Napa), Chinese mustard cabbage , cauliflower , collard , kale , kohlrabi , mustard greens , mustard spinach , rape greens : downy mildew, 3 days. ^a Chinese waxgourd , citron melon , cucumber , gherkin , gourd (edible), Momordica spp. muskmelon , pumpkin , summer and winter squash , watermelon : downy mildew, 0 days (12 hours). Ginseng : <i>Phytophthora</i> root rot, <i>Alternaria</i> leaf blight, 31 days. ^a Read and follow label directions. Leafy vegetables (except Brassica vegetables): downy mildew, 3 days. ^a Onion (dry bulb): downy mildew, 7 days. ^a Tomato : <i>Phytophthora</i> root rot, damping-off (<i>Pythium</i> spp.).
Iprodione ^c (Rovral)	Beans : ^d gray mold (<i>Botrytis</i>), white mold (<i>Sclerotinia</i>). Broccoli : blackleg. Carrot : <i>Alternaria</i> blight, black crown rot, no more than 4 applications. Chinese mustard : <i>Alternaria</i> leaf spot, no more than 4 applications. Garlic : white rot, no more than 1 application. Lettuce : lettuce drop and bottom rot, no more than 3 applications, 14 days. ^a Onion (dry bulb): <i>Botrytis</i> leaf blight, <i>Botrytis</i> neck rot, and <i>Alternaria</i> purple blotch, no more than 5 applications. Potato : early blight and white mold, no more than 4 applications, 14 days. ^a The following crops may be rotated after harvest: beans , broccoli , carrot , garlic , lettuce , onion (dry bulb), peanut , potato . The following crops may be rotated 1 month following the last iprodione application: cotton , root crops , tomato . Read and follow label directions.
Mefenoxan (Apron XL LS)	Beets , carrots , legume vegetables and okra , spinach : seed treatment for control of <i>Pythium</i> and <i>Phytophthora</i> causing damping-off, seed rot, and systemic downy mildew diseases. Read and follow label directions for these uses, as well as seed treatments for export.

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
Mefenoxan (cont.) (Ridomil Gold EC)	<p>Asparagus: Phytophthora crown and spear rot. Read and follow label directions.</p> <p>Beans (all), lentils, peas, soybeans (edible): Pythium damping-off and root rot. When applied preplant and incorporated in the top 2 inches of soil with a surface application, or in a 7-inch band at planting. Read and follow label directions.</p> <p>Cole crops: Pythium damping-off and Phytophthora basal stem rot. Surface applications may be broadcast at planting, incorporated into the upper 2 inches of soil. Seven-inch band applications are also labeled. Read and follow label directions.</p> <p>Cucurbits: Pythium damping-off and cottony leak. Applications may be in a 7-inch band over the row at planting or broadcast. Broadcast applications should be incorporated into the top 2 inches of soil. Read and follow label directions.</p> <p>Lettuce (head), onion, spinach: Pythium damping-off. Apply either broadcast or banded at planting. Read and follow label directions.</p> <p>Eggplant, pepper: Pythium damping-off, Phytophthora crown rot, 7 days.^a</p> <p>Root and tuber vegetables (beet, carrot, radish, sweet potato): Read and follow label directions.</p> <p>Tomato: Pythium damping-off, as well as Pythium and Phytophthora fruit and root rots. Apply either broadcast or banded immediately before or after planting. Incorporate with irrigation. Read and follow label directions.</p>
(Ridomil Gold GR)	<p>Leafy vegetables (excluding spinach), lettuce (head and leaf): Pythium damping-off. Applications may be made banded over the row or preplant incorporated. Read and follow label directions.</p> <p>Spinach: Pythium damping-off, white rust (<i>Albugo occidentalis</i>), and downy mildew. Applications may be made preplant incorporated or preemergence. Read and follow label directions.</p> <p>Tomato: Pythium damping-off. Pythium and Phytophthora fruit and root rots, 7 days.^a Read and follow label directions.</p>
(Ridomil Gold Bravo)	<p>Broccoli, Brussels sprout, cabbage, cauliflower: downy mildew and Alternaria leaf spot, 7 days.^a Read and follow label directions.</p> <p>Cucumber, melon, squash: downy mildew, anthracnose, Cercospora leaf spot, gummy stem blight (black rot), leaf blight, and scab. Read and follow label directions.</p> <p>Onion^c (dry bulb, seed, and green): downy mildew, Botrytis leaf blight (blast), and purple blotch; dry, 7 days, and green, 21 days.^a Read and follow label directions.</p> <p>Potato: late blight and early blight, storage rots (Pythium leak; pink rot caused by <i>Phytophthora</i>), 14 days.^a Read and follow label directions.</p> <p>Tomato: late blight and early blight, Phytophthora fruit rot, gray leaf spot, gray leaf mold, Septoria leaf spot, Anthracnose, Alternaria fruit rot (black mold), Rhizoctonia fruit rot, and Botrytis gray mold, 14 days.^a Read and follow label directions.</p>
(Ridomil Gold Copper)	<p>Carrot, radish: diseases caused by oomycetes, 7 days.^a Read and follow label directions.</p>

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
Mefenoxan (cont.) (Ridomil Gold Copper) (cont.)	Cucurbits: downy mildew, 5 days. ^a Read and follow label directions. Onion (dry bulb, seed, and green), garlic: downy mildew: dry, 10 days, and green, 7 days. ^a Read and follow label directions. Pepper: Pythium damping-off, Phytophthora crown rot, 7 days. ^a Read and follow label directions. Potato: late blight and early blight, storage rots (Pythium leak; pink rot caused by <i>Phytophthora</i>), 7 days. ^a Read and follow label directions. Spinach: white rust and downy mildew, 21 days. ^a Read and follow label directions. Tomato: Phytophthora fruit rot, late blight, 14 days. ^a Read and follow label directions.
(Ridomil Gold MZ)	Cucumber, melon, summer squash: downy mildew, 5 days. ^a Read and follow label directions. Onion (dry bulb): downy mildew, 7 days. ^a Read and follow label directions. Potato: late blight and early blight, storage rots (Pythium leak; Phytophthora pink rot), 14 days. ^a Read and follow label directions. Tomato: late blight, 5 days. ^a Read and follow label directions.
(Ridomil Gold PC)	Beans (dry and green): ^d damping-off and seed and seedling rots caused by <i>Pythium</i> and <i>Rhizoctonia</i> . Apply 12 oz per 1,000 ft of row at planting time. Read and follow label directions.
Metalaxyl (Allegiance FL)	Beets, carrot, cucumber, seed and pod vegetables, spinach, sweet corn, and popcorn: seed treatment for the control of Pythium damping-off and in certain crops for early-season <i>Phytophthora</i> control. Read and follow label directions for these uses, as well as seed treatments for export use.
Oxamyl (Vydate L)	Carrot, cucurbits, eggplant, pepper, potato, sweet potato: for nematode control. Apply before or at planting. Apply in transplant water for pepper or as foliar spray for pepper and vine crops, 7 days. ^a Read and follow label directions.
PCNB (Terraclor)	<i>Field use</i> — Beans (dry, snap, succulent): protective fungicide for control of root and stem rot caused by <i>Rhizoctonia solani</i> . Spray planting furrow and covering soil at planting. Apply only at planting time and avoid spraying directly on seed. Read and follow label directions. Broccoli, Chinese broccoli, Brussels sprout, cabbage, Chinese cabbage (tight-heading only), cauliflower: for control of clubroot and wirestem or black root. For effective control of clubroot, thoroughly mix Terraclor with the soil. Read and follow label directions. Garlic: soil and clove treatment at planting for white rot. Read and follow label directions. Hot pepper (direct seeded): in-furrow application for control of root and stem rot caused by <i>Rhizoctonia solani</i> . Read and follow label directions. Pepper, tomato: transplant solution or soil treatment at planting for control of Southern blight. Read and follow label directions.

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
PCNB (cont.) (Terraclor)	<i>Bedding plants</i> — Beans, broccoli, Brussels sprout, cabbage, cauliflower, pepper, tomato: soil drench to seedlings grown in containers or beds prior to transplanting for the control of root/stem rot and damping-off caused by <i>Rhizoctonia solani</i> and <i>Pellicularia filamentosa</i> . Read and follow label directions.
Propiconazole (Tilt)	Celery: early blight (<i>Cercospora</i>), late blight (<i>Septoria</i>), 14 days. Read and follow label directions. Corn (sweet and pop): Helminthosporium leaf blights, rusts, grey leaf spot, and eyespot. Sweet corn, 14 days. ^b Do not apply more than 16 fl oz per acre. Do not apply to popcorn after silking. Do not harvest for forage within 14 days of application for sweet corn or 30 days for popcorn. Read and follow label directions.
Streptomycin	Beans: halo blight, seed treatment. Pepper, tomato: apply at 2-leaf stage (200 ppm spray). Potato: seed-piece treatment only (100 ppm dip or dust). Soak cut seed pieces less than 30 min. Do not use treated seed for food or feed. Read and follow label directions.
Sulfur	Exempt when used with good agricultural practices. See label.
Terbufos (Counter 15G)	Corn (sweet and pop): apply in band or furrow at planting. Read and follow label directions.
Thiabendazole (Mertect 340F)	Carrot: storage rot (gray mold and white mold) control. Sweet potato: treatment of seed against black rot, scurf, and foot rot. Do not use treated roots for food or feed. Potato: seed-piece treatment to control <i>Fusarium</i> tuber rot. Do not treat seed potatoes after cutting. Read and follow label directions.
Thiophanate methyl (TOPS 2.5D, TOPS 5, and MZ)	Potato: seed-piece treatment. Read and follow label directions.
(Topsin-M70W, Topsin M4.5F)	Beans: white mold and gray mold. Snap or dry beans, 14 days ^a ; lima, 28 days. ^a Cucurbits: anthracnose, gummy stem blight, powdery mildew, and target spot, 0 days. ^a Onion: white rot. Apply in-furrow at planting. Read and follow label directions.
Thiram	Beans, beet, broccoli, Brussels sprout, cabbage, cantaloupe, carrot, castor beans, cauliflower, collard, corn (sweet), cucumber, eggplant, endive, kale, kohlrabi, lettuce, mustard, okra, onion, peas, pepper, pumpkin, radish, spinach, squash, Swiss chard, tomato, turnip, watermelon: seed treatment. WARNING: Do not use treated seed for food, feed, or oil.

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
Thiram (cont.)	Onion: furrow treatment. Tomato: for leaf spots and fruit rot, 0 days. ^a Read and follow label directions.
Triphenyltin (Super Tin 80WP)	Potato: early and late blight, 21 days. ^a May be applied through irrigation systems (solid set or center pivot only). Read and follow label directions.
Vinclozolin (Ronilan)	Beans (snap, common, and lima): gray mold, white mold, 14 days. ^a Do not make more than 2 applications per season or more than 2 pounds of the product per season. Read and follow label directions. Lettuce (head or leaf): Sclerotinia drop, 28 days. ^a No more than 6 lb/A/season. Onion (dry): white rot, Botrytis blight, neck rot, 18 days. ^a No more than 10 lb/A/season.
Ziram (Ziram 76DF)	Tomato (not cherry tomato): anthracnose, early blight, Septoria leaf spot, 7 days. ^a Do not apply more than 24 pounds of product per acre per crop cycle. Read and follow label directions.

^aNumber of days between last application and harvest.

^bThere are many other copper materials, but these are most widely available and labeled for use on vegetable crops. Exempt from tolerance if used with good agricultural practices; not exempt if used at the time of harvest or after harvest. See label.

^cPhytotoxicity to crop or follow-up crop. See label.

^dDo not feed treated tops or forage to livestock.

Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2000

Vegetable and disease	Disease management practices
ASPARAGUS	
Crown or root rots, seedling blights, and wilt	No resistant varieties are available for control of these diseases. Treating the crowns with mancozeb may aid in control. <i>Phytophthora</i> can be controlled using Ridomil Gold EC applied over the bed. These diseases are best managed by good asparagus culture. Provide optimal soil fertility and weed, insect, and rust control. Avoid excessive cutting. Avoid acidic (low-pH) and poorly drained soils.
Rust, Cercospora, and other leaf and branchlet blights	Grow rust-resistant varieties. Apply mancozeb to nonharvested fields up to August 15 and to harvested fields only after harvest. Applications should be made at 7- to 10-day intervals. Control is needed in 1- and 2-year beds, even with resistant varieties.
BEANS (SNAP, DRY WAX, AND LIMA)	
Most diseases	When possible, use rotations of 2 to 3 years or longer between bean crops and practice strict sanitation.
Seed decay, damping-off, seedborne stem blights, and root rots	Plant only western-grown, certified seed in a seedbed that is warm (60° to 65°F), well prepared, and well drained. Treat seed with Allegiance FL, Apron XL plus thiram, or captan and an insecticide. In-furrow sprays of Ridomil Gold (EC or PC) or seed treatment with Apron XL may be helpful for early season root-rot control. Ridomil Gold EC or PCNB may be used to help control <i>Rhizoctonia</i> .
Root rots	Pythium root rot can be controlled using Ridomil Gold (EC or PC) as a band or furrow treatment at planting. Maintain optimal soil fertility. Utilize rotations of at least 2 to 3 years with other crops.
Bacterial blights	Plant only western-grown, certified seed. Utilize crop rotations of 2 to 3 years. Avoid cultivating when beans are wet. Field applications of 2 to 4 lb of fixed copper (for example, Kocide 101) per acre provide good control of brown spot and halo blight, but only moderate control of common or fuscous blight. Do <i>not</i> use copper on fresh-market lima beans. Streptomycin can be used as a seed treatment to control halo blight.
Rust, anthracnose, and other fungal leaf, pod, and stem diseases	Utilize crop rotations of 2 to 3 years. Apply Bravo at 7- to 10-day intervals starting when disease first appears. Rust-resistant varieties are available for some types of beans. Sulfur also may be used but may be phytotoxic at high temperatures.
Gray mold	Apply Benlate (except for snap bean), Bravo, Rovral, or Topsin-M at 25% bloom, and repeat at full bloom. Thorough coverage of blossoms is essential.
White mold	Apply Benlate (except for snap bean), Rovral, or Topsin-M at 25% bloom, and repeat at full bloom.
Mosaic virus diseases	Plant varieties with resistance to bean common mosaic, NY15 strain of common mosaic, and bean yellow mosaic. Avoid planting near clovers, birdsfoot trefoil, gladiolus, and so forth.

Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2000 (cont.)

Vegetable and disease	Disease management practices
BEANS (SNAP, SRY WAX, AND LIMA) (CONT.)	
Soybean cyst nematode	Rotate at least 2 to 3 years with corn, small grains, alfalfa, or other nonhost crop. Do <i>not</i> include soybeans in the rotation. Temik may be used on dry beans.
Root-knot and lesion nematodes	Apply Mocap (snap or lima beans) or Temik (dry beans only) at planting.
BEET (GARDEN), SWISS CHARD	
Seed rot, damping-off, and seedborne leaf spot	Sow in a well-prepared seedbed. Treat seed with Apron XL or Allegiance FL (for <i>Pythium</i>), captan, or thiram. Make sure boron levels are adequate. Several soluble-boron formulations are available.
Cercospora leaf spot	Apply fixed copper weekly at the first sign of disease. Separate new from old plantings.
CARROT, PARSNIP	
Seed rot, damping-off	Treat seed with captan or thiram. Plant in well-drained seedbed. Avoid overwatering. Apron XL and Allegiance FL can be used to control <i>Pythium</i> damping-off on carrot.
Cercospora leaf spot, Alternaria leaf blight	Apply Bravo or Rovral at 7- to 10-day intervals. Start when disease first threatens and repeat as needed.
White mold	Use a crop rotation of 3 to 4 years.
Aster yellows	Use insecticides to control leafhoppers that transmit the mycoplasma. Excellent early season leafhopper control is essential. Control must occur before leafhoppers feed.
Root-knot nematode	Fumigate mineral soils with Telone II or Vapam; or practice a 3-year rotation with corn or other nonhost crops. Control broadleaf weed hosts. Vydate L (carrot only) may be applied at planting in-furrow or broadcast 1 week before planting.
Parsnip canker, leaf spot, and mildew	Spray with fixed copper 3 times at 10-day intervals at first sign of disease. Ridge soil over the shoulders to prevent canker infections.
CELERY, PARSLEY	
Seed rot, damping-off, and seedborne leaf blights	Treat seed with hot water, then captan or thiram. If damping-off starts, spray 2 to 3 times at 5- to 7-day intervals with Bravo (celery only) or fixed copper. Seed 2 to 3 years old is free of late blight.
Leaf blights and spots (celery only)	Spray Benlate or Bravo at 7- to 10-day intervals.
Aster yellows and root-knot nematode	See the section on carrot and parsnip.
CORN (SWEET AND POP)	
Seed rot, seedling blights, and seedborne diseases	Plant seed treated with captan or thiram plus an insecticide. Plant shallow in warm, well-drained soil.

Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2000 (cont.)

Vegetable and disease	Disease management practices
CORN (SWEET AND POP) (CONT.)	
Goss's bacterial wilt	Use 2- to 3-year crop rotations when using susceptible corn (dent or sweet) varieties.
Stewart's disease	Plant resistant varieties, or control corn flea beetles on young plants with an insecticide.
Smut	Plant tolerant varieties. Control corn borers as first tassels appear.
Maize dwarf mosaic, chlorotic dwarf, and wheat streak mosaic	Control johnsongrass and volunteer wheat. Plant wheat after the fly-free date. Plant resistant or tolerant varieties.
Helminthosporium leaf blights and anthracnose leaf blight	Plant resistant varieties. Spray Bravo, mancozeb, maneb, or Tilt when disease first appears. Crop rotation and clean tillage help reduce disease risk.
Rusts	Plant resistant varieties. Spray as for Helminthosporium blights.
Nematodes	Apply Counter or Mocap (sweet corn only) at planting time.
CRUCIFER CROPS (BROCCOLI, BRUSSELS SPROUT, CABBAGE, CAULIFLOWER, CHINESE CABBAGE, COLLARD, KALE, KOHLRABI, MUSTARD, RADISH, RUTABAGA)	
Seed rot, damping-off, black rot, blackleg, Alternaria leaf spot	Sow only western-grown, hot water-treated seed. Seed also should be treated with thiram or captan. Place seedbeds where no crucifer has grown for 4 years or more and where water will not drain from fields recently planted to crucifers. Ridomil Gold (EC or WSP) applied at planting time controls Pythium damping-off and Phytophthora basal stem rot.
Wirestem (Rhizoctonia)	Incorporate PCNB-captan in the upper 3 in. of soil before planting, or drench after planting.
Clubroot	Use only healthy transplants. Avoid soils with a history of clubroot. If clubroot is present, adjust soil pH to 7.2 with hydrated lime. Rotate out of cruciferous crops for 7 years. Apply PCNB (Terraclor 75WP) in transplant water or as a band or broadcast application.
Black rot and blackleg	Use certified, hot water-treated seed. Use a crop rotation of 4 years or more. Use care in selecting plant bed sites. Be sure no drainage occurs to the seedbed from old plantings. Control wild mustard and other cruciferous weeds. Purchase only certified, disease-free transplants, and do not dip before planting. Sprays of fixed copper may help control black rot. Rovral may be used to control blackleg on broccoli. Bravo applied to control downy mildew also may help control blackleg. Some cabbage varieties resistant to black rot are available. Losses are generally lower where direct seeding is used.

Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2000 (cont.)

Vegetable and disease	Disease management practices
CRUCIFER CROPS (BROCCOLI, BRUSSELS SPROUT, CABBAGE, CAULIFLOWER, CHINESE CABBAGE, COLLARD, KALE, KOHLRABI, MUSTARD, RADISH, RUTABAGA) (CONT.)	
Downy mildew, <i>Alternaria</i> leaf spot, and other fungal leaf diseases	Rotate with noncruciferous crops and use disease-free seed or transplants. Apply Bravo, maneb, or Ridomil Gold Bravo at weekly intervals. Start applications in seedbed or when plants are young. Aliette and Ridomil Gold EC may be used to control downy mildew on some cruciferous crops.
Internal tip burn	Plant resistant varieties. Avoid overfertilizing, especially with nitrogen.
Fusarium yellows	Plant only yellows-resistant varieties.
Radish black root	Plant resistant varieties. Avoid planting radishes in severely infested soil.
Nematodes	Mocap (cabbage only) or Nematicur (Brussels sprout and cabbage only) may be applied at planting.
CUCURBITS (CUCUMBER, MUSKMELON OR CANTALOUPE, PUMPKIN, SQUASH, WATERMELON)	
General	Use a crop rotation of 3 to 4 years. Grow resistant varieties whenever possible.
Seed rot, damping-off, and seedborne diseases	Plant only certified, western-grown seed treated with captan or thiram. Ridomil Gold EC can be used as a broadcast or banded soil application.
Bacterial wilt	Provide season-long control of striped and spotted cucumber beetles. Start as the plants begin to emerge. Planting-time treatment with Furadan provides moderate control for 3 to 4 weeks. Supplemental insecticide use is necessary.
Anthracnose, scab, blossom blights, gummy stem blight, and black rot	Grow resistant varieties when possible. Spray weekly with Benlate, Bravo, mancozeb, maneb, or Topsin M. Quadris can be used for anthracnose and gummy stem blight. Follow label directions. Start when vines begin to run. Store only blemish-free fruit.
Downy mildew and <i>Alternaria</i> leaf blight	Practice a 2- to 3-year rotation. Grow resistant varieties when possible. Maintain ample but not excessive nitrogen fertility. Apply Bravo, mancozeb, or maneb weekly. Ridomil Gold Bravo provides excellent control of downy mildew. Quadris can be used to control these diseases. Follow label directions.
Fruit spots and rots	Maintain fungicide schedule as for anthracnose throughout the season. Avoid harvest injuries.
Fusarium wilt	Grow only resistant varieties.
Angular leaf spot	Practice crop rotations of 3 to 4 years. Resistant cucumber varieties are available. Apply fixed-copper sprays in combination with Bravo. Start applications early in the season.

Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2000 (cont.)

Vegetable and disease	Disease management practices
CUCURBITS (CUCUMBER, MUSKMELON OR CANTALOUPE, PUMPKIN, SQUASH, WATERMELON) (CONT.)	
Powdery mildew	Apply chlorothalonil when plants are in the first true leaf stage or when conditions are favorable for disease development. Quadris is applied on a one-to-one alternation with a fungicide having a different mode of action. Where Benlate is applied to control other diseases, powdery mildew is controlled under moderate disease pressure. Plant resistant varieties where possible.
Mosaic viruses	Control aphids and beetles in the field. Eliminate broadleaf weeds around field borders before plant establishment. Plant only mosaic-resistant cucumbers.
Root-knot nematode	Fumigate with Vapam, Telone C-17, or Telone II in the fall before planting; or use Furadan or Vydate L at planting.
EGGPLANT	
Seed rot, damping-off, and seedborne diseases	Plant hot water-treated seed when possible. Treat the seed with captan or thiram. Ridomil Gold EC may be used for Pythium damping-off.
Phomopsis blight, Alternaria leaf spot, Cercospora leaf spot, and anthracnose	Follow good sanitary practices. Use a crop rotation of 2 to 3 years. Avoid bruising fruit; handle carefully at all times. Apply maneb at 7- to 10-day intervals, beginning at first fruit cluster.
Verticillium wilt and nematodes	Fumigate the soil with Vapam or methyl bromide plus chloropicrin. Planting under a black plastic mulch helps reduce disease severity. Vydate L controls nematodes.
HORSERADISH	
Leaf spots and white rust	Practice a 2-year field rotation with any other crop. Apply fixed-copper fungicides. Start when conditions are wet or dews are heavy. Continue until a killing frost occurs.
Brittleroot	Plant clean sets. Control leafhoppers that spread the disease agent.
LETTUCE, ENDIVE, ESCAROLE	
Seed rot, damping-off, and gray mold	Treat seed with captan or thiram. Ridomil Gold (EC or GR) as a soil application at seeding controls Pythium damping-off on head lettuce.
Aster yellows and mosaic viruses	Control leafhoppers and aphids throughout the season. Early season control is most important.
Rhizoctonia bottom rot, Sclerotinia drop, and gray mold	Plant on raised beds, and deep-plow when possible. Apply Ronilan or Rovral at the 3-leaf stage and again 10 and 20 days later. Use 100 gal of water carrier per acre.
Nematodes	Apply Telone C-17, Telone II, or Vapam in the field in the fall before planting. In greenhouses, steaming the soil provides control.

Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2000 (cont.)

Vegetable and disease	Disease management practices
OKRA	
Seed rot and damping-off	Treat seed with captan or thiram plus Apron XL. Plant in warm, well-drained soil. Apron XL and Allegiance FL can be used to control Pythium damping-off.
Fusarium and Verticillium wilts	Fumigate soil with Vapam or methyl bromide plus chloropicrin.
ONIONS, GARLIC, LEEK, CHIVES, SHALLOT	
Smut, seed rot, and damping-off	Treat the seed with captan or thiram. Use Methocel sticker to pellet the seed with fungicide. Use 1½ lb of active ingredient to 20 lb of seed for set onions and 6 lb of active ingredient to 8 lb of seed for bulb onions. Mancozeb or Ridomil Gold EC may be used as an in-furrow drench at planting.
Blast, downy mildew, Alternaria purple blotch, and Botrytis neck rot	Apply Bravo, mancozeb (dry onions only), maneb, Ronilan, or Rovral weekly. Begin spraying with the first ozone alert. Continue until harvest. Use Ridomil Gold Bravo or Ridomil Gold MZ (dry onions only) when downy mildew appears.
Bulb and stem nematode and root-knot nematode	Fumigate with Telone C-17, Telone II, or Vapam. Eradicate volunteer plants from fields with a history of bulb and stem nematode.
White rot of garlic	Apply Rovral on cloves and in-furrow covering soil. Plant disease-free cloves in well-drained soil.
Fusarium basal rot	Avoid heavily infested fields. Grow resistant varieties. Cure bulbs rapidly and properly.
Storage decays	Maintain excellent control of leaf diseases in the field. Maintain dry storage conditions.
Yellow dwarf	Control aphids. Keep old and new plantings as far apart as possible. Destroy volunteer onions.
PEAS	
Seed rot and seedling and seedborne diseases	Plant western-grown seed treated with captan or thiram and Apron XL plus an insecticide, Apron XL or Allegiance FL. Graphite at 1 oz per bushel may be added to reduce friction in the drill.
Root rots	Index production fields. Avoid planting in fields with an index of 75 or higher. In fields with a lower root-rot index, apply dinoseb (Premerge 3) or trifluralin preplant incorporated. Ridomil Gold EC in the seed furrow gives good Pythium damping-off and root-rot control.
Fusarium wilt and near wilt and viral diseases	Grow resistant varieties. Viruses are spread by aphids. Plant as early as possible in well-fertilized and well-drained soil. Rotate 4 or more years.
Powdery mildew	Apply sulfur dust or spray when mildew first appears and temperatures are less than 80°F. Two applications, a week apart, provide good control. Plant resistant varieties.

Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2000 (cont.)

Vegetable and disease	Disease management practices
PEPPER	
Seed rot, damping-off, and seedborne diseases	Use only western-grown seed and treat with hot water or a household bleach (Clorox) soak. The bleach soak helps control seedborne bacterial spot. Using 1 part bleach to 3 parts water, soak 1 minute. Use 1 gal of fresh solution to 1 lb of seed. Rinse thoroughly before treating with captan or thiram seed protectant. Ridomil Gold EC may be used to control Pythium damping-off.
Bacterial spot	Use crop rotations of 2 to 3 years, excluding tomatoes. Control broadleaf weeds in and around field borders. Apply fixed copper plus streptomycin (200 ppm) to seedlings. After transplanting, apply fixed copper at 5- to 7-day intervals. The addition of maneb to the copper can increase the effectiveness of the application. Purchase only certified, disease-free transplants. Maintain a high, balanced level of soil fertility.
Phytophthora crown rot	Plant on raised beds in well-drained soil. Treat soil with Ridomil Gold EC. Rotate to nonsolanaceous crops for 3 to 4 years.
Anthracnose, Cercospora leaf spot, other fungal leaf spots, and fruit rots	Use disease-free seed. Practice 3-year crop rotation. Burn or plow down crop refuse after harvest. Apply maneb at 7- to 10-day intervals when disease first appears.
Nematodes	Add Vydate L to transplant water and supplement with foliar applications. Follow label directions.
Verticillium wilt	Fumigate soil with Vapam or methyl bromide plus chloropicrin.
Viral diseases	Grow resistant varieties. Control aphids that transmit viruses. Eliminate broadleaf weeds within 150 ft of fields before crop is established. Plant only healthy transplants.
POTATO (IRISH)	
General	Purchase only certified seed. Seed-production fields should be inspected for viral, nematode, and fungal disease problems. Good sanitation and seed-handling practices reduce losses.
Seed-piece decay, seedborne diseases, Verticillium wilt, and blackleg	Treat seed with captan, mancozeb, maneb, or TOPS 2.5D. Keep seed storage at approximately 40°F during the winter. In the spring, warm the seed to 65° to 70°F for 2 to 3 weeks before cutting. Streptomycin may be added to fungicide dusts to improve the control of bacterial diseases. Avoid bruising seed during handling.
Scab	Plant resistant varieties. Do <i>not</i> apply manure or other organic matter immediately before the potato crop. Maintain acidic soil.
Storage rots	Store healthy, sound, unbruised mature potatoes. Maintain a proper storage environment. Apply Mertect 340-F as a spray to unwashed tubers before storage to help control Fusarium dry rot.

Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2000 (cont.)

Vegetable and disease	Disease management practices
POTATO (IRISH) (CONT.)	
Rhizoctonia	Use a Terraclor soil treatment. Practice a 3-year rotation. Avoid deep planting.
Verticillium wilt	Practice crop rotation and use only seed free of <i>Verticillium</i> . Control root-knot and root-lesion nematodes. Soil fumigation with Vapam may be practical.
Nematodes	Where soil samples indicate damaging levels of nematodes, apply Temik or Vydate L, or fumigate with Telone C-17 or Vapam.
Early blight and late blight, leak, and pink rot	Apply Bravo, mancozeb, or maneb on a 5- to 10-day schedule. Maintain an adequate supply of nitrogen throughout the season to provide good control of early blight. Use Ridomil Gold Bravo or Ridomil Gold MZ only where late blight, leak, and pink rot are threats. Avoid bruising tubers, especially in hot weather.
Viral diseases and purple-top wilt (Aster yellows)	Plant only certified seed. Control aphids and leafhoppers with insecticides. Practice clean cultivation. Rogue first-infected plants, including tubers.
RHUBARB (GREENHOUSE ONLY)	
Botrytis leaf rot	Apply fixed copper after budding and at weekly intervals.
Crown and root rots	Plant only in well-drained soil. Maintain optimal soil fertility. Drench the crowns with fixed copper at 3 lb per acre in the early spring and after harvest if crown rot is a problem.
SPINACH	
Seed rot and damping-off	Treat seed with captan or thiram. Apply Ridomil Gold EC for Pythium damping-off.
Downy mildew and white rust	Grow downy mildew-resistant varieties. Apply Aliette as a foliar spray when conditions favor disease development, and continue on a 7- to 21-day interval. A soil application of Ridomil Gold EC can also help control downy mildew and white rust. Ridomil Gold Copper can be used to control these diseases. There is a 21-day preharvest interval for both Ridomil Gold products. Read and follow label directions.
Cucumber mosaic virus or blight	Grow tolerant varieties. Control aphids that spread the virus.
SWEET POTATO	
Black rot, root rot, Fusarium wilt, and scurf	Grow resistant varieties. Use clean soil in plant beds and maintain a temperature of 80° to 85°F. Plant disease-free roots and use crop rotations of 3 to 4 years. Dip the roots or sprouts in Mertect 340-F.
Storage rots	Fumigate storage crates and houses with formaldehyde. Cure and store only healthy, blemish-free roots.
Nematodes	Plant resistant varieties. Practice crop rotation. Mocap, Temik, or Vydate L may be used for chemical control; or fumigate in the fall with Vapam.

Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2000 (cont.)

Vegetable and disease	Disease management practices
TOMATO (FIELD)	
Seed decay, damping-off, and seedborne diseases	Plant seed that has been soaked in hot water or household bleach and that has been treated with captan or thiram. See treatment for pepper seed. Use Ridomil Gold EC drench for Pythium damping-off in the seedbed.
Bacterial spot, speck, and canker	Purchase only certified, disease-free plants. Use crop rotations of 3 to 4 years, excluding peppers. In the seedbed, spray with fixed copper plus streptomycin. After transplanting, spray with fixed copper plus mancozeb or Bravo. Once established, bacterial spot and canker are difficult to control.
Septoria blight, early blight, anthracnose, buckeye rot, gray leaf spot; leaf mold, gray mold, and white mold (<i>Sclerotinia</i>)	Practice 2- to 3-year crop rotation. Apply Bravo, mancozeb, or Quadris on a 7- to 10-day schedule after the first sign of disease or after the first fruits form. A soil-surface spray of mancozeb after the last cultivation improves anthracnose control. Benlate may be used for Botrytis, white mold, and leaf mold control. Ridomil Gold EC or Ridomil Gold Bravo helps control buckeye rot, Pythium fruit rots, and late blight. Ziram can be used to control anthracnose, early blight, and Septoria leaf spot.
Late blight	Avoid planting tomatoes near potatoes. Destroy potato tuber cull piles and volunteer potato plants near tomato plantings. Plant disease-free, certified transplants. Practice good field sanitation. Apply Ridomil Gold Bravo or Ridomil Gold MZ on 14-day intervals; or apply Bravo, mancozeb, or Quadris on 5- to 7-day intervals.
Blossom-end rot	Mulch plants or maintain uniform soil moisture. Four weekly applications of calcium nitrate starting when fruits are grape sized may reduce losses. Avoid cultivation close to plants.
Verticillium and Fusarium wilts	Grow only resistant (VF) varieties. Avoid soils with a history of wilt.
Viral diseases	Take care to avoid infecting seedlings. Start with virus-free seed. Control insects and broadleaf weeds in and around fields. See upcoming entry on greenhouse tomatoes.
Nematodes	Plant root knot-resistant varieties. Vydate L may be applied at planting. Fall fumigation with Vapam also may be used.
TOMATO (GREENHOUSE)	
Viral diseases	Start with hot water-treated seed. Do not allow the use of tobacco on the premises. Smokers should wash their hands with soap and hot water before working with plants. If possible, plant TMV-resistant hybrids. Control insects. Remove the first infected plants if possible.
Botrytis gray mold, leaf mold, gray leaf spot, and early blight	Avoid excessive humidity by heating and venting, especially at night during the fall, early winter, and early spring. Spray weekly with Bravo, mancozeb, or Ziram.
Nematodes, root rots, and soilborne TMV	Steam the plant beds. Plant resistant varieties whenever available.