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**Table 12: Yields of Vegetable Crops**

Crop	Expected Yields in Tons per Acre		
	Average	Good	Excellent
Asparagus	1	1.5	2
Bean, snap	2	3	4
Cabbage	13	15	20
Cantaloupe	10	15	19
Cucumber (slicing)	9	12	15
Cucumber (pickling, hand harvest)	6	10	12
Onion	13	18	23
Pepper, green	14	17	20
Potato (fall)	10	15	20
Pumpkin	10	15	25
Spinach	6	8	10
Summer squash	10	13	16
Sweet corn	4.5	8	10
Sweet potato	7	12	15
Tomato (fresh market)	11	13	15
Tomato (processing)	25	29	33
Watermelon	15	20	25

This table only provides general yield estimates for new or prospective growers. The USDA-National Agricultural Statistics Service Vegetable Survey provides more accurate information.

## Table 13: Postharvest Handling and Storage Life of Fresh Vegetables

A lack of adequate refrigeration and cooling will shorten the shelf-life and lower the quality of fresh vegetables. Cucumber, eggplant, lettuce, green or ripe pepper, potato, snap bean, summer squash, and tomato are among the most susceptible vegetables to chilling or freezing injury. Some cold injury symptoms that can make vegetables unmarketable. The most typical include pitting, water-soaked spots, browning, surface decay, and, in pepper and tomato, failure to ripen.

The following list of recommended storage condition information is adapted from *The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks* (USDA-ARS Agriculture Handbook Number 66, www.ba.ars.usda.gov/hb66/contents.html), *Knott's Handbook for Vegetable Growers* (Donald N. Maynard and George J. Hochmuth, 5th ed., 2007), and "Properties and Recommended Conditions for Long-Term Storage of Fresh Fruits and Vegetables" (Marita Cantwell, University of California-Davis, Postharvest Technology webpage, postharvest.ucdavis.edu).

Vegetable	Storage Conditions		
	Temperature (°F)	Relative Humidity (%)	Relative Storage Life
Asparagus	36	95-100	2-3 weeks
Beans, snap	40-45	95	7-10 days
Beets & carrots, bunched	32	98-100	10-14 days
Broccoli	32	95-100	10-14 days
Cabbage, late	32	98-100	5-6 months
Cantaloupe	36-41	95	2-3 weeks
Cauliflower	32	95-98	3-4 weeks
Cucumber	50-54	85-90	10-14 days
Eggplant	50-54	90-95	1-2 weeks
Greens — collards, kale, & spinach	32	95-100	10-14 days
Lettuce	32	98-100	2-3 weeks
Okra	45-50	90-95	7-10 days
Onions, dry	32	65-70	1-8 months
Onions, green	32	95-100	3 weeks
Peas, in pods	32	90-98	1-2 weeks
Peas, southern	40-41	95	6-8 days
Pepper, green	45-55	90-95	2-3 weeks
Pepper, ripe	42-45	90-95	1 week
Potato, early	<sup>a</sup>	90-95	<sup>a</sup>
Potato, late	<sup>b</sup>	90-95	<sup>b</sup>

Vegetable	Storage Conditions		
	Temperature (°F)	Relative Humidity (%)	Relative Storage Life
Pumpkin	54-59	50-70	2-3 months
Radish	32	95-100	1-2 months
Rhubarb	32	95-100	2-4 weeks
Squash, summer	40-45	95	1-2 weeks
Squash, winter	54-59	50-70	<sup>c</sup>
Sweet corn	32	95-98	2-5 days, up to 21 days for supersweet cultivars
Sweet potato	55-59	85-95	4-7 months
Tomato, light red	50-55	90-95	1 week
Tomato, mature-green	50-60	90-95	1-2 weeks
Tomato, firm-ripe	46-50	85-90	3-5 weeks
Turnip root	32	95	4-5 months
Watermelon	50-60	90	2-3 weeks

<sup>a</sup>Most summer-harvested potatoes are not stored. However, they can be held 4-5 months at 40°F if cured 4-5 days at 60-70°F before storage. They can be stored 2-3 months at 50°F without curing. Potatoes for chips should be held at 70°F or conditioned for best chip quality.

<sup>b</sup>Fall-harvested potatoes should be cured at 50-60°F and high relative humidity for 10-14 days. Storage temperatures for seed or table stock should be lowered gradually to 38-40°F. Potatoes intended for processing should be stored at 50-55°F. Those stored at lower temperatures or with a high reducing sugar content should be conditioned at 70°F for 1-4 weeks or until trial cooking tests are satisfactory.

<sup>c</sup>Winter-squash varieties differ in storage life. Acorn squash can be stored for 35-55 days, butternut squash for 60-90 days, and Hubbard squash for 180 days.

## Table 14: Conversions for Liquid Pesticides on Small Areas

Rate per Acre	Rate per 1,000 Square Feet	Rate per 100 Square Feet
1 pint	0.75 tablespoon	0.25 teaspoon
1 quart	1.5 tablespoons	0.5 teaspoon
2 quarts	3 tablespoons	1 teaspoon
1 gallon	6 tablespoons	2 teaspoons
25 gallons	4.5 pints	1 cup
50 gallons	4.5 quarts	1 pint
75 gallons	7 quarts	1.5 pints
100 gallons	9 quarts	1 quart

Check the pesticide label for the particular crop, pest, and site of your planned use.

**Table 15: Germination and Growing Guide for Vegetable Plants and Herbs**

Crop	No. of Seeds per Oz	Opt. Germination Temp. (°F)	Usual Day Temp. (°F)	Min. Night Temp. (°F)	Time for Uniform Germination (days)
Asparagus	700	75			10-21
Broccoli	9,000	68-86	65-70	60	5-10
Brussels sprouts	9,000	68-86			5-10
Cabbage	9,000	85	65	60	5-10
Chinese cabbage	18,000	85			3-7
Cauliflower	9,000	80	65-70	60	5-10
Celery	72,000	70	65-70	60	10-21
Collards	9,000	68-86			3-10
Cucumber	1,100	68-86	70-75	65	3-7
Dandelion (for greens)	35,000	68-86			7-21
Eggplant	6,500	85	70-85	65	7-14
Endive	27,000	68-86	70-75	70	5-14
Kale	9,000	68-86			3-10
Leek	11,000	68			6-14
Lettuce	25,000	75	60-65	40	7
Okra	500	68-86			5-14
Pak-choi	18,000	68-86			3-7
Parsley	18,500	75			11-28
Pepper	4,500	85	70-75	60	6-14
Sweet potato plants (from tuberous roots bedded in sand)		77	75-85		14-21
Squash	400	80-90	70-75	65	4-7
Tomato	11,500	85	65-75	60	5-14
<b>Herbs</b>					
Anise	9,600	70			5
Basil, dark opal	20,000	70			10
Basil, leaves	9,600	70			10
Borage	2,100	70			8
Chives	22,000	60			10
Coriander	1,240	70			10
Dill	6,300	60			10
Fennel, sweet	4,000	65			10
Marjoram, sweet	100,000	70			8
Rosemary	30,000	60			15
Sage	3,250	70			15
Thyme	96,000	75			10

## Pesticide Use in Greenhouses and High Tunnels

Vegetable production in greenhouses and high tunnels has increased throughout the Midwest. Although insects and mites you find in greenhouses may differ from those you find in the field, using pesticides will be necessary to suppress pest populations and prevent plant damage. However, it is important to use pesticides properly in order to maximize performance.

There are three key factors associated with maximizing pesticide performance in greenhouses or high tunnels:

1. Timing
2. Coverage
3. Frequency

### 1. Timing

It is important to apply insecticides and miticides at the most susceptible life stage of the target insect or mite pest. Generally, the most susceptible life stages for many contact pesticides are the larva, nymph, and adult. The egg and pupa tend to be more resilient, and so less susceptible to pesticides. For this reason, effectively controlling an insect or mite pest means you must understand the pest's biology.

When applying systemic insecticides to the soil or growing medium, always apply them before you notice phloem-feeding insects (such as aphids and whiteflies). That's because the systemic insecticide's active ingredient may take time to move or translocate throughout plants. That movement depends on water solubility (the higher the water solubility, the faster the active ingredient will translocate through the plant vascular system).

Take note that temperature influences a pest's life cycle (and thus the presence of its susceptible life stages). The higher the temperature, the faster insects and mites develop. So before you apply, consider the effect temperature has had on insect and mite development.

You also want to minimize harm to honey bees. Apply pesticides in the early morning before honey bees are active, or apply them on cloudy, overcast days when honey bees are less active.

### 2. Coverage

Coverage is particularly important when using contact pesticides. Always try to obtain thorough coverage of all plant parts — including the leaves, stems, and flowers. This way, wet sprays will come in contact with insect and mite pests.

To enhance coverage, you may need to use an adjuvant to improve its spreading ability. Adjuvants are added to pesticide mixtures or solutions to improve or alter deposition, toxicity, mixing ability, persistence, and other attributes that will enhance performance. One type of adjuvant is a surfactant, which reduces the surface tension of spray droplets. This allows the spray to better cover waxy or hairy leaf surfaces of certain plants or the outer coverings (cuticles) of insects and mites. Remember, a number of vegetable crops have waxy leaf surfaces.

### 3. Frequency

How often you spray will depend on the pesticide's residual activity. Always read pesticide labels to learn how often it should be applied. In general, recommendations usually call to apply pesticides once every seven days. However, the actual application frequency depends on a pesticide's residual activity (short-term vs. long-term).

Be aware that too many applications may injure certain vegetable crops. For example, phytotoxicity may occur if you apply insecticidal soaps (potassium salts of fatty acids) or horticultural oils (mineral, petroleum, or neem-based) too frequently (three times per week). Furthermore, applying the same pesticide continuously may promote resistance in the pest populations, so always rotate pesticides with different modes of action.

The time of year or season (spring vs. summer) also may affect the frequency of applications. Again, that's because of temperature's influence on the life cycle of the insect or mite pest. As the ambient air temperature increases, it takes less time to complete the life cycle (egg to adult). So high temperatures may require more frequent applications.

State pesticide regulatory agencies in the Midwest have different interpretations of whether a high tunnel is considered a type of greenhouse. For example, Indiana considers a high tunnel to be a type of greenhouse, which means that pesticides labeled for use in a high tunnel may be appropriate for a greenhouse. Other states may consider high tunnels to be the same as fields in terms of pesticide use. And states like Missouri have a variable definition. A high tunnel is considered a greenhouse when the sides are closed, but is classified as a field when the sides are open.

In short, be sure how your state classifies high tunnels.

For greenhouse pesticide applications, there are three label interpretations, which are presented in Table 16.

The first interpretation is that the pesticide label clearly states that the product can be used in greenhouses and must be used according to label directions.

The second interpretation is that the pesticide labels clearly prohibits greenhouse use. Therefore, you should never use these pesticides in a greenhouse.

The third interpretation is that many pesticide labels do not specify whether they can be used in greenhouses. When labels do not prohibit greenhouse use, most state regulatory agencies allow the pesticide can be used in a greenhouse as long as the treated crop is on the label and the pesticide is applied according to label directions.

**Table 16: Insecticide Labeling for Greenhouse Use<sup>1</sup>**

Labeled for Greenhouse Use	Label Prohibits Greenhouse Use	Label Does Not State Greenhouse Use
Admire PRO <sup>®</sup>	Actara <sup>®</sup>	Acramite <sup>®</sup>
Agree <sup>®</sup> (and other <i>Bacillus thuringiensis</i> products)	Coragen <sup>®</sup>	Agri-Mek <sup>®</sup>
Avaunt <sup>®2</sup>	Di-Syston <sup>®</sup>	Ambush/Pounce <sup>®</sup> / Permethrin <sup>®</sup>
Dibrom <sup>®3</sup>	Diazinon <sup>®</sup>	Ammo <sup>®</sup>
DiPel <sup>®</sup>	Dimethoate <sup>®</sup>	Asana <sup>®</sup>
Entrust <sup>®</sup>	Movento <sup>®</sup>	Assail <sup>®</sup>
Exirel <sup>®</sup>	Orthene <sup>®</sup>	Baythroid <sup>®</sup>
Intrepid <sup>®</sup>	Platinum <sup>®</sup>	Belay <sup>®</sup>
Lannate <sup>®</sup>	Proclaim <sup>®</sup>	Beleaf <sup>®</sup>
Monitor <sup>®</sup>	Radiant <sup>®</sup>	Brigade <sup>®</sup>
M-Pede <sup>®</sup>	Trigard <sup>®</sup>	Closer <sup>®</sup>
Neemix <sup>®</sup>	Voliam Flexi <sup>®</sup>	Cryolite <sup>®</sup>
Sevin <sup>®</sup>	Voliam Xpress <sup>®</sup>	Danitol <sup>®</sup>
Vydate <sup>®</sup>	Voliam Flexi <sup>®</sup>	Fulfill <sup>®</sup>
		Hero <sup>®</sup>
		Knack <sup>®</sup>
		Kryocide <sup>®</sup>
		Larvin <sup>®</sup>
		Leverage <sup>®</sup>
		Lorsban <sup>®</sup>
		Malathion <sup>®</sup>
		Mustang Maxx <sup>®</sup>
		Oberon <sup>®4</sup>
		PennCap-M <sup>®</sup>
		Rimon <sup>®5</sup>
		Sivanto <sup>®</sup>
		sulfur
		Venom <sup>®</sup>
		Warrior <sup>®</sup>

<sup>1</sup>For example, a tomato grower in the field can use any of the 19 products on pages 143-144 to treat hornworm in tomato. The same grower could use 16 products in the greenhouse (three products prohibit greenhouse use, the others specifically mention greenhouse use or do not mention greenhouse use).

<sup>2</sup>Not for brassicas.

<sup>3</sup>Additional restrictions for greenhouse use.

<sup>4</sup>Oberon 2SC only.

<sup>5</sup>Only for greenhouse tomatoes.

**Table 17: Fungicide Labeling for Greenhouse Use<sup>1</sup>**

Labeled for Greenhouse Use	Label Prohibits Greenhouse Use	Label Silent on Greenhouse Use
Agri-mycin <sup>®</sup>	Aprovia Top <sup>®</sup>	Actigard <sup>®</sup>
Botran <sup>®</sup>	Cabrio <sup>®</sup>	Agri-Fos <sup>®</sup>
Champ <sup>®</sup>	chlorothalonil <sup>2</sup>	Blocker <sup>®</sup>
Contans <sup>®</sup>	Endura <sup>®</sup>	Curzate <sup>®</sup>
Cuprofix <sup>®</sup>	Flint <sup>®</sup>	Gavel <sup>®</sup>
Dithane <sup>®</sup>	Forum <sup>®</sup>	Gem <sup>®</sup>
Fontelis <sup>®</sup>	Merivon <sup>®</sup>	Harbour <sup>®</sup>
Kocide	Presidio <sup>®</sup>	Inspire Super <sup>®</sup>
Luna Tranquility <sup>®6</sup>	Priaxor <sup>®</sup>	Luna Experience <sup>®</sup>
Previcur Flex <sup>®</sup>	Pristine <sup>®</sup>	Luna Sensation <sup>®</sup>
Procure <sup>®</sup>	Proline <sup>®</sup>	Manzate <sup>®</sup>
Ranman <sup>®3</sup>	Quadris <sup>®</sup>	Monsoon <sup>®</sup>
Scala <sup>®6</sup>	Quadris Opti <sup>®</sup>	Omega <sup>®</sup>
Serenade Opti <sup>®</sup>	Quintec <sup>®</sup>	Orondis Ultra <sup>®6</sup>
Terrachlor <sup>®4</sup>	Rally <sup>®</sup>	OSO 5% <sup>®</sup>
	Reason <sup>®</sup>	Penncozeb <sup>®</sup>
	Orondis Gold <sup>®</sup>	Phostrol <sup>®</sup>
	Orondis Opti <sup>®</sup>	Quadris Top <sup>®5</sup>
	Ridomil <sup>®</sup>	Quilt <sup>®</sup>
	Satori <sup>®</sup>	Revus <sup>®</sup>
	Vapam <sup>®</sup>	Revus Top
	Zampro <sup>®</sup>	Rovral <sup>®</sup>
	Zing <sup>®</sup>	Switch <sup>®</sup>
		Tanos <sup>®</sup>
		Toledo <sup>®</sup>
		Torino <sup>®</sup>
		Vivando <sup>®</sup>
		Ziram <sup>®</sup>

<sup>1</sup>For example, a tomato grower in the field can use any of the products listed in the entries on pages 135-136 to treat early blight of tomato. In a greenhouse, the same grower could not use Cabrio<sup>®</sup>, any product with chlorothalonil, Endura<sup>®</sup>, Quadris<sup>®</sup>, Quadris Opti<sup>®</sup>, or Zing<sup>®</sup> (these product labels prohibit greenhouse use). In the greenhouse, the grower may use the other products because the label either specified that it could be used (mancozeb products such as Dithane<sup>®</sup>, or Scala<sup>®</sup>), or the label did not mention use in the greenhouses (mancozeb products such as Manzate<sup>®</sup>/Penncozeb<sup>®</sup>, or Gavel<sup>®</sup>, Inspire Super<sup>®</sup>, OSO 5%<sup>®</sup>, Revus Top<sup>®</sup>, Tanos<sup>®</sup>, Switch<sup>®</sup>, or Ziram<sup>®</sup>).

<sup>2</sup>All products with the active ingredient chlorothalonil are prohibited in the greenhouse including Bravo<sup>®</sup>, Echo<sup>®</sup>, and Equus<sup>®</sup>.

<sup>3</sup>For use on basil and tomato transplants only.

<sup>4</sup>Use only on bedding plants grown in containers.

<sup>5</sup>Do not use for transplant production.

<sup>6</sup>For use on tomato only.

<sup>7</sup>See comment in Leafy Vegetables section.