Producing Vegetable Transplants as Bedding Plants
Michigan State University Extension Service
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Producing Vegetable Transplants as Bedding Plants

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Vegetable transplants are a growing segment of the bedding plant industry. Starting tender seedlings in the greenhouse lets the home gardener have success with a wider selection of vegetable crops. Vegetable transplants are used as alternatives to direct-seeding which allows warm-season crops such as tomatoes, peppers and eggplants that are sensitive to cool temperatures to reach maturity in our climatic zone. Also, the use of transplants generally insures a more uniform stand than can be obtained through direct-seeding.

This bulletin is for both the new bedding plant grower just getting started in the business and the established grower who wishes to include vegetable transplants for retail sale to the home gardener.

Vegetable Crops

Determining which crops can be grown in a particular area depends on many factors. Two of the most important are frost-hardiness and length of growing season.

Hardiness: Vegetables may be classified as either cool-season or warm-season crops. Cool-season vegetables grow best at moderate (70-80°F) daytime temperatures and can withstand short periods of mild frost. Many warm-season crops which grow best with warmer daytime temperatures (75-90°F), are damaged by exposure to air temperatures below 40°F and are injured severely by frost. Some will not recover from sustained exposure to chilling temperatures.

The table, Vegetable Hardiness in the Field or Garden, indicates the relative cold-hardiness of several vegetable crops.

Growing Season: Vegetable crops vary in the length of growing season required to produce a crop. Generally, growing season is defined by the number of days between the last frost of the spring and the first killing frost of the fall. In most crops, flexibility has been provided by the development of early- or late-season varieties.

Selecting Varieties

Choosing the correct vegetable varieties to grow for bedding plants can be a complex task. Commonly grown vegetables, such as tomatoes, are represented in the market by many long established varieties as well as new introductions. Others, like Brussels sprouts, have a limited selection.

Length of growing season, local growing conditions and consumer preferences must be of primary concern in choosing varieties for transplant sale. Varieties also may be selected for disease or insect resistance, size of fruit, and whether they will be used for fresh consumption or processing.

Vegetable Hardiness in the Field or Garden

Cool Season	Hardy	Half-hardy
	Broad beans	Cauliflower
	Broccoli	Chard
	Brussels sprouts	Chinese cabbage
	Cabbage	Lettuce
	Celery	
	Collards	
	Kale	
	Kohlrabi	
	Onion	
Warm Season	**Tender**	**Very Tender**
	Snap bean	Cucumber
	Sweet corn	Eggplant
	Tomato	Muskmelon
		Pepper
		Pumpkin
		Squash
		Watermelon

Days from Seeding to Harvest Under Ideal Conditions

Crop	Season Early	Season Late	Crop	Season Early	Season Late
Broccoli	55	78	Lettuce, butterhead	55	70
Brussels sprouts	90	100	Lettuce, leaf	40	50
Cabbage	62	120	Melon, honeydew	—	110
Cauliflower	50	125	Muskmelon	85	95
Chard, Swiss	50	60	Onion, dry	90	130
Chinese cabbage	70	80	Onion, green	45	60
Collard	70	85	Pepper	65	80
Corn, sweet	64	95	Pumpkin	100	120
Cucumber, pickling	48	58	Squash, summer	40	50
Cucumber, slicing	62	72	Squash, winter	85	110
Eggplant	50	80	Tomato	60	90
Kale	—	55	Watermelon	75	95
Kohlrabi	50	60			

Seed to Field or Garden Transplant

Crop	Min. Day temp. (F)	Night temp. (F)	Time (weeks)
Broccoli	60-70	50-60	4-6
Brussels sprouts	60-70	50-60	4-6
Cabbage	60-70	50-60	4-6
Cantaloupe	70-75	60-65	3-4
Cauliflower	60-70	50-60	4-6
Celery	65-75	60-65	8-10
Cucumber	70-75	60-65	2-3
Eggplant	70-80	65-70	5-6
Lettuce	55-65	50-55	4-6
Onion	60-65	55-60	10-12
Pepper	65-75	60-65	6-8
Squash, summer	70-75	60-65	2-3
Sweet corn	70-75	60-65	3-4
Tomato	65-75	60-65	5-7
Watermelon	70-80	65-70	2-3

The Vegetable Varieties table contains listings of recommended varieties for Michigan. Additional selections may be found in Extension Bulletins E-760a, "Variety Recommendations for Michigan Gardens" and E-675, "Vegetable Varieties for Commercial Growers."

Propagation of Vegetable Seedlings

Timing: The date for sowing is determined by the anticipated date of sale. This varies depending on the frost-free date in the area and the frost tolerance of the vegetable.

Flexibility in scheduling may be provided by managing the growing conditions of the seedlings. However, take care to avoid starting seeds too far in advance of sales. Plants held too long awaiting sale may become tall, spindly and rootbound. Seedlings, especially sweet corn, may be injured if allowed to grow too large before transplanting and may produce poorly.

Seed Quality: Success in growing vegetable transplants largely depends on the quality of the seed used. After selecting varieties adapted to your region, obtain fresh seed with a high germination rating. Seed stored for more than one season has a lower germination rate and reduced seedling vigor. Depending on the crop, some seeds may need chemical or heat treatments for disease control.

Open Flats

Generally, sow seeds in rows and cover with a layer of fine sand or vermiculite. Supplemental bottom heat in the form of heating pads or cables may be required for certain crops. Keep all seed trays uniformly moist because germination and seedling growth are very moisture

VEGETABLE VARIETIES

BROCCOLI
Baccus
Green Comet
Cruiser
Emperor
Galaxy
Packman
Premium Crop
Southern Comet

BRUSSELS SPROUTS
Green Marvel
Jade Cross Strain E
Lunet
Prince Marvel
Rubine *(red)*

CABBAGE
Bravo
Conquest
Danish Ballhead
Gourmet
Green Winter
Market Prize
Rio Verde
Savoy Ace
Savoy King
Stonehead
Superette

(Red)
Red Danish
Red Head
Ruby Ball

(Processing type)
King Cole
Roundup

CABBAGE, CHINESE
Jade Pagoda
Le Choi Pak Choi
Two Seasons

CAULIFLOWER
Greenball
Imperial 10-6
Purplehead
Royal Purple
Self Blanche
Snow Crown
Snow Pak
Taipan
White Fox
White Rock
White Top

CELERY
Deacon
Florida 683
Green Giant
Ventura
Utah 52-70R

CUCUMBERS
(Pickling)
Bush Pickle
Calypso
Carolina
Earlypik
Green Star
Lucky Strike
Picklebush
Regal
Reliance
Score
Tamor
Triple Crown

(Slicing)
Burpless
Burpee Hybrid
Dasher II
Marketmore 70
Marketmore 76
Pacer
Raider
Salad Bush
Slicemaster
Sweet Success

EGGPLANT
Black Beauty
Black Magic
Burpee Hybrid
Classic
Dusky
Ichiban

LETTUCE
(Butterhead and Bibb)
Bibb
Buttercrunch
Dark Green Boston
Summer Bibb
Tania
Tom Thumb

(Romaine)
Parris Island
Valmaine

(Head Lettuce)
Green Lake
Ithaca
Mintello
Raleigh
South Bay

(Leaf)
Crispy Sweet
Deep Red
Grand Rapids
Ruby
Slobolt
Waldmanns Green

MUSKMELONS
Ambrosia
Burpee Hybrid
Classic
Earli-Sweet
Gold Star
Saticoy
Summet
Superstar

ONIONS
(Yellow Sweet)
Golden Treasure
Sweetheart
Sweet Sandwich
Yellow Sweet Spanish

(Red)
Benny's Red
Ruby

PEPPERS
(Bell—Sweet)
Annabelle
Bell Boy
Big Belle
Canape
Four Corners
Jupiter
Keystone Resistant
Lady Bell
Staddons Select
Sweet Belle
Yolo Wonder

(Processing—Sweet)
Cubanelle
Long Yellow Sweet
Pimento Perfection
Red Cherry Sweet
Rumanian Sweet
Sweet Banana

(Processing—Hot)
Goldspike
Hungarian Yellow Max
Jalapeño
Red Cherry Hot
Rumanian Wax

SQUASH (Summer)
(Green)
Burpee Hybrid
Caserta
Elite
Gourmet Globe
President
Select
Senator

(White)
Patty Pan

(Yellow)
Dixie
Early Prolific
Gold Rush
Lemondrop L
Seneca Prolific
Sundance
Yellow Crookneck

TOMATOES
Determinate
(Medium to large fruit)
Duke
Jackpot
Mountain Pride
Pik-Red
Spring Set VF
Sunny

Indeterminate
(Large fruit)
Beefmaster VFN
Floramerica

(Medium to large fruit)
Burpee Big Early
Early Girl
Golden Boy
Vineripe VFN

(Small fruit)
Burpee's Pixie
Red Cherry Large
Small Fry VFN
Sweet 100
Tiny Tim

WATERMELONS
Crimson Sweet
Jubilee
Mirage
Royal Jubilee
Sugar Baby
Summer Festival
Sweet Baby

sensitive. Proper spacing is important because crowding may cause seedlings to become weak and spindly and it promotes rapid spread of diseases.

Plug Trays

Vegetable transplants may also be produced in plug flats which vary from 96 to 614 cells per tray. The longer the plants must be kept in the plug tray, the lower the number of plugs per flat to allow adequate room for root growth. If the cell is too small, the seedlings may become stunted resulting in reduced plant quality and lower yields.

Most of the plugs used commercially for field plantings are either 96 or 200 cells per flat. If the vegetables are to be sold as transplants to homeowners, the plugs are usually transplanted to flats with between 18 and 72 plants per flat.

The same requirements exist for germination in open flats or plug trays. It is essential to keep the seed moist, to provide air spaces in the medium, to maintain a proper temperature and to germinate in the presence of light. Because of the small volume of media in a plug, it is more difficult to maintain adequate air and water conditions than in a seed flat. Therefore, close observation and proper care is essential for success with plugs.

Environmental Conditions

Each vegetable crop has unique requirements for optimum seed germination and may require different handling techniques. Seed sizes may differ significantly among crops making seeding operations more complex. Certain seeds, such as celery and some lettuce varieties, require light for germination while others must be covered. Optimum temperatures for germination also vary from crop to crop.

The Germination Guide lists major germination requirements for several vegetable crops.

Transplanting from Open Flats

Generally, when the first set of true leaves are fully expanded, it is time to transplant the seedlings from the seeding trays to individual or pack containers. Handle seedlings by the leaf rather than the stem because leaves are replaced if damaged, but injury to the stem is permanent and can be lethal. Take care to minimize root loss. Keep the transplants shaded and moist for a few days to reduce transplant shock.

Vegetable crops respond differently to the stresses of being transplanted. Cucumbers, melons and other cucurbits are difficult to transplant, so seed them directly into individual containers such as peat pellets or pots. In this way, the entire container may be planted to minimize root disturbance. Sweet corn can be germinated early for transplanting, but plants should not be allowed to grow too long in the flat before planting out.

Sanitation

Sanitation is a key to the success of commercial plant propagation. Since many plant pathogens are soil-borne, it is essential that all media be pasteurized or treated with fungicides before use to prevent damping-off. Equipment and facilities such as flats, pots, seeders, benches and misters should be cleaned thoroughly with a chlorine bleach solution (1 part chlorine bleach to 9 parts water) before each crop.

Seed Germination Media

The best seed germination media is fine-textured but must also be porous to allow for adequate air exchange. Examples of media that fit this criteria are peat-lite mixes and fine sphagnum. The pH should be around 6.2 to 6.5 and the media must be pathogen-free to avoid damping-off and other disease problems.

Transplant Media: A typical bedding plant peat-lite mix to use as a transplant media would include:

*a. One cubic yard of 50% peat/ 50% perlite or vermiculite by volume.**

b. 5 pounds fine dolomitic lime.

c. 2 pounds superphosphate (0-20-0).

d. 1 pound potassium nitrate.

e. 2 pounds osmocote (14-14-14).

f. 3 fluid ounces wetting agent.

g. 4 tablespoons of fritted trace elements or a manufacturer recommended amount of a microelement mix.

A typical soil-based mix would contain the following:

a. 1/3 cubic yard of loam soil.

b. 1/3 cubic yard of sphagnum peat.

c. 1/3 cubic yard of perlite.

d. 2 pounds of superphosphate (0-20-0).

e. adjust the pH to 5.8-6.0 by adding dolomitic limestone to raise the pH or add $FeSO_4$ to lower it.

Either mix must provide good aeration, drainage and moisture retention capability. The peat-lite mixes give the most consistent results.

*Example: one cubic yard = 27 cubic feet or 22 bushels (11 bushels peat and 11 bushels vermiculite). However, 15-20% shrinkage occurs in mixing so you must add an extra 4 bushels for a total of 26 to maintain the proper volume.

Fertilization

Once the seedlings have developed roots, proper fertilization is important for good growth. Have the initial media or soil mix tested by a laboratory to obtain a complete analysis so that necessary adjustments may be made *before* planting.

While the transplants are growing, the pH and soluble salts levels in the media should be spot checked weekly (*before* fertilizing) using a pH meter and solubridge. A desirable range for conductivity of soluble salts in a 1 part media to 2 parts *distilled* water mixture is 0.5 to 0.8 μmhos. If the salts are below 0.3 μmhos, the soil is deficient and should be fertilized. Above 0.8, the soil contains excessive salts and should be leached.

Transplant Fertilization: Fertilizer may be applied to the transplants at low levels at every watering or less frequently at higher levels. The ***Constant Liquid Fertilization*** or ***Fertigation*** method provides fertilizer at a concentration of 75-150 ppm nitrogen at ***every*** watering. Under an ***Interval Fertilization*** program, fertilizer at the rate of 200 ppm N is applied at 7 to 10 day intervals or as the crop shows signs of needing fertilizer.

Adjust the level of fertilization to maintain good color and adequate growth rates. The fertilization level may also vary according to light and temperature conditions. Plants will be stunted and yellowish in color if under-fertilized and may be excessively tall, lush and susceptible to certain disorders if over-fertilized.

The rate of transplant growth and the corresponding fertilizer requirements are influenced by water availability and application techniques. Once seedlings are established, allow the surface of the media to dry slightly between irrigations.

Environmental Conditions

To produce stocky, healthy vegetable transplants, the temperature, ventilation and light supply must be well managed.

Temperature: Optimal growth temperatures vary by crop. Seedlings grown in temperatures above the optimum range will be tall and spindly. Those experiencing excessively low temperatures may be stunted.

Monitor temperatures by placing a number of calibrated thermometers at various places around the greenhouse. For accuracy, shade and aspirate the thermometers. Adjust the heating and ventilation systems as necessary to maintain the desired conditions.

Ventilation: A properly managed ventilation system helps control temperature, humidity

Germination Guide

Crop	Seeds per oz.	Light req.	Soil temp. (F)	Days to germ.	Seeding to first transplant (weeks)
Broccoli	9,000	D or L	68-86	3-10	2.5
Brussels sprouts	9,000	D or L	68-86	3-10	2.5
Cabbage	9,000	D or L	68-86	3-10	2.5
Cantaloupe	1,200	D or L	68-86	4-10	DS
Cauliflower	9,000	D or L	68-86	3-10	2.5
Celery	72,000	L	65-70	10-21	3
Collards	4,500	D or L	68-86	3-10	3
Cucumber	1,100	D or L	68-86	3-7	DS
Eggplant	6,500	D or L	68-86	10-14	3
Lettuce	25,000	L	68-70	5-7	2.5
Onion	9,000	D or L	68	6-10	DS
Pepper	4,500	D or L	68-86	6-14	3
Squash	400	D or L	68-86	4-7	DS
Tomato	9,500	D or L	68-86	5-14	3
Watermelon	300	D or L	68-86	4-14	DS

DS = Direct Seed in Pots or Pellets
D = Darkness
L = Light

Relative Ease of Transplanting to the Field

Easy	Moderate	Require Special Care*
Broccoli	Celery	Sweet corn
Brussels sprouts	Eggplant	Cucumber
Cabbage	Onion	Muskmelon
Cauliflower	Pepper	Summer squash
Chard		Watermelon
Lettuce		
Tomato		

*Seeding in pots, bands or peat pellets is recommended to minimize disturbance during transplanting into the garden.

and carbon dioxide levels. Adequate air circulation around the plants is essential to prevent diseases, but avoid the introduction of cold drafts. A horizontal air flow system using strategically placed fans keeps the air circulating in the greenhouse and prevents moisture condensation on the leaf surfaces.

Light: Light level is a major factor in the type and amount of growth produced by the plants. The type of greenhouse covering is a major factor in determining light levels. Fluorescent or high intensity discharge lights may be feasible for use over germination benches, but they are generally not economical for large scale use in the greenhouse. In early spring, it is important to make the maximum use of the generally low light levels. Shading compounds, shade cloths or opaque coverings may be needed during late spring to aid in temperature control when light intensities begin to increase.

Hardening Temperatures

Cool-season crops	50-60°F for 5 days
Tomatoes, peppers, eggplant, vine crops	Not below 55°F

Hardening Off: Acclimate transplants to minimize the shock of being moved from the greenhouse to the field. The growth rate of the plants should be slowed and the cuticle layer thickened by a *gradual* reduction in water, temperature and fertilizer. Take care while making such reductions to avoid excessive stress to the transplants. Pay particular attention to warm-season crops such as tomatoes, peppers or eggplants which may be set back by exposure to cool temperatures.

Insects and Pests

The following pests may be present during bedding plant production:

Aphids: Aphids are light-colored, crawling insects that suck plant juices and cause stunted growth or a general decline in plant vigor. They often appear on growing tips or under leaves and secrete sticky honeydew which may support a black, sooty mold growth. Warmer temperatures speed their life cycle and magnify the problem.

Mealybugs: These are small, pinkish, sucking insects that produce a white, cottony mass often found in the leaf axils. They secrete sticky honeydew which may support a black, sooty mold growth. Mealybug infestations may produce distorted growth and premature leaf drop.

Nematodes: Nematodes are microscopic worms which attack roots and, occasionally, other plant parts. The best control is good sanitation, especially the use of sterile rooting media.

Scales: These sucking insects cover themselves with a white, brown or black waxy substance. Scales also secrete sticky honeydew which may support sooty mold growth.

Slugs and Snails: Soft-bodied, crawling pests that feed at night, slugs and snails leave a trail of slime and create large holes in the leaves. They are more prevalent under high moisture conditions.

Spider mites: Spider mites are extremely small pests related to the spider family which suck juices from the plants. They tend to reproduce more rapidly at higher temperatures.

Thrips: Thrips are very small insects which are difficult to see without a hand magnifying lens. They feed on unfolding leaves, flowers and flower buds and leave irregular white spots which give plants a silvery appearance.

Whiteflies: These tiny white flying insects are often found on the underside of leaves. Whiteflies are sucking insects which produce honeydew.

See Extension Bulletin E-1276, "Insect Controls for Michigan Commercial Greenhouse and Bedding Plant Production," for chemical control measures.

Diseases

The following diseases may be problems during bedding plant production:

Damping Off: Damping off causes sudden death of young seedlings and spreads in a circular pattern in the seed tray. It is often caused by *Rhizoctonia* or *Pythium* fungi. It may be controlled by using pasteurized media or treating media with a fungicide *before* seeding.

Tobacco Mosaic Virus: Solanaceous crops such as tomatoes and eggplant are very susceptible to tobacco mosaic virus. Because it is often carried in tobacco products, prohibit all smoking or other use of tobacco while in the greenhouse.

Powdery Mildew: Gray, fuzzy-looking superficial growth that appears on leaves and stems, powdery mildew is a more serious problem under high humidity and cloudy conditions. Fungicides and increased air circulation may be effective controls for this problem.

Several diseases are common to individual types of vegetable crops such as wirestem and black rot in cole crops or bacterial canker in tomatoes. For specific

Problems Occurring During Transplant Culture

Problem	Possible cause(s)	Suggested remedy
Plants are off color, appear light green.	Low nutrient level.	Apply complete liquid fertilizer. Check total salts.
	High soluble salts.	Leach if level is too high.
	Waterlogged soil.	Raise packs to improve drainage.
	Temperature too low.	Raise temperature.
Chlorosis with interveinal yellowing.	Root injury.	Apply iron but also try to correct underlying cause.
	Improper media pH.	Have media analyzed and make adjustment.
	Over or underwatering.	Correct watering practices.
	High soluble salts.	Leach the media.
	Trace element deficiency.	Apply trace elements.
	Ammonium toxicity.	Raise temperature or use nitrate nitrogen form.
Uneven growth.	Nonuniform distribution of fertilizer and/or water.	Use liquid fertilizers and proper watering practices.
	Nonuniform moisture levels at transplanting.	Prewet containers 24 hours before transplanting.
	High soluble salts.	Leach the media.
	Poor grade of seedlings.	Select uniform-sized plants for each pack.
Purple leaves.	Phosphorus deficiency.	Test media prior to transplanting. Add high P fertilizer.
	Temperature too low.	Check minimum night temperatures in the greenhouse.
Seedlings fall over.	Damping off.	Use only sterile media or use a fungicide drench before transplanting. Improve the air circulation.
Slow growth.	Low nutrient level.	Test media and apply appropriate fertilizer.
	Temperature too low.	Increase temperature especially at night.
	Moisture too low.	Water more frequently.
Tall and spindly growth.	Too much nitrogen.	Test the media. Check calibration of proportioner.
	Temperature too high.	Lower temperature and improve ventilation.
	Excess water.	Reduce watering.
	Low light intensity.	Keep covering clean or replace. May need artificial lighting.

symptoms and controls, refer to the publications listed at the end of this bulletin which deal with the individual crops.

The Cooperative Extension Service has many other publications on bedding plants, vegetables and related subjects. Call or write your county Cooperative Extension Service office for a catalog of available publications, or write to:
MSU Bulletin Office
Michigan State University
P.O. Box 6640
E. Lansing, MI 48826-6640

Following is a partial listing of some of the related bulletins available at your county Extension office:

E-0312 *1987 Control of Insects, Diseases and Nematodes on Commercial Vegetables* (88 pp.) $2.00
E-0760B *Home Vegetable Garden Disease, Insect Control* (52 pp.) $.80
E-0968 *Cole Crop Insect Pests* (2 pp.) free
E-0969 *Cucumber, Melon, Squash and Pumpkin Insect Pests (2 pp.) free*
E-1275 *Chemical Controls for Michigan Commercial Greenhouse/Bedding Plant Production* (12 pp.) $.55
E-1276 *Insect Controls for Michigan Commercial Greenhouse/Bedding Plant Production* (2 pp.) $.55
E-1287 *Control of Mosses and Algae Under Greenhouse Conditions* (2 pp.) free
E-1400 *Identifying Major Pests of Greenhouse Bedding Plants* (4 pp.) $.45
E-1427 *Disease and Insect Pests of Celery* (8 pp.) $1.50
E-1668 *Disorders of Cole Crops* (4 pp.) $.55
E-1679 *Disorders of Tomatoes* (16 pp.) $1.00
E-1720 *Diseases of Carrots* (28 pp.) $.80
E-1721 *Diseases of Onions* (40 pp.) $1.15
E-1736 *Greenhouse Growth Media—Testing/Nutrition Guidelines* (6 pp.) free
E-1750 *The Glasshouse Ornamental Disease Control Handbook* (68 pp.) $.90
E-1751 *Identifying Diseases of Vegetables* (68 pp.) $10.00
E-1815 *Peppers—Commercial Vegetable Recommendations* (4 pp.) free
E-1872 *Rearing Predator Mites for Orchards and Glasshouses* (12 pp.) $1.60
E-1943 *Bacterial Canker of Tomatoes* (4 pp.) free
E-2014 *Insect and Mite Management in Commercial Greenhouses* (80 pp.) $2.00
E-2014S *Insect and Mite Management in Commercial Greenhouses Supplement* (16 pp.) free
E-2017 *Chemical Disease Controls for Michigan Greenhouse Industry* (poster) $3.25

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