Aster yellows is caused by a mycoplasma carried by the aster leafhopper (Macrosiphis floridensis). It is primarily a disease of lettuce, celery and carrots, but it also infects onion. Onions infected with the disease have soft, small bulbs and long, yellow-green leaves. The bulbs do not dry well during curing and often sprout in storage because they do not become dormant. Under extreme disease conditions, infection may approach 5 to 10 percent. The main problem caused by the disease is poor drying of onion bulbs in storage, which may lead to subsequent rots. Because the disease is transmitted from infected weed and crop hosts by leafhoppers, it can be controlled only by reducing the presence of host plants near onions and controlling the leafhoppers in host crops. It is of little value to spray onions to control aster leafhoppers.

Weeds
Weed control is a major expense and concern in onion production. Onions are very poor competitors, and weed pressure any time before bulb formation will reduce yields. Weeds that emerge late in the season keep onion leaves from drying quickly and interfere with harvest. A good weed control program consists of pre- and post-emergence herbicide applications. Once or twice a season it may be necessary to remove by hand large weeds that have escaped herbicide applications. Cultivation at the two- to four-leaf stage may remove some weeds and help aerate the soil.

Pesticide Information
Pesticides must be registered with the U.S. Environmental Protection Agency (EPA) and the Michigan Department of Agriculture before they can be used legally in Michigan. Purchase only pesticides that are labeled for the crop to be treated and the pest to be controlled. Remember that the pesticide label is a legal document on pesticide use, and all instructions and limitations on it must be followed closely. The use of a pesticide in a manner not consistent with the label can lead to injury of crops, humans, animals and the environment, and can lead to civil fines and/or condemnation of the crop.

Additional Information
More information on onion production is available in the following bulletins, available from county MSU Extension offices, or from the MSU Bulletin Office, 10-B Agriculture Hall, East Lansing, Michigan 48824-1039. (All orders totaling less than $100 must be prepaid.)

E-312 – Control of Insects, Diseases and Nematodes on Commercial Vegetables.
E-550B – Fertilizer Recommendations for Vegetable Crops in Michigan.
E-800 – Nematode Detection.
E-972 – Lettuce and Onion Insect Pests.
E-1409 – Temperature and Humidity Guides to Curing and Storing Onions.
E-1721 – Diseases of Onions.
E-1751 – Identifying Diseases of Vegetables.

Cooperative Extension Service • Michigan State University Extension Bulletin E-1307 (Revision)

Commercial Vegetable Recommendations

ONIONS

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Production and Use

The average yield of U.S. No. 1 pungent yellow onions in Michigan is 16.5 tons (660–50-lb bags) per acre. With irrigation and good cultural practices, it is possible to obtain marketable yields of 20 to 25 tons (800 to 1,000 50-lb bags) per acre. Spanish onions from transplants yield 500 to 550 bags per acre. Green onions yield 8 to 10 tons (1,000 to 1,200 boxes) per acre. Most Michigan onions are packed for fresh market, either soon after harvest or from storage.

Climatic Requirements and Irrigation

Onion is a biennial plant, forming a bulb the year of planting seed and a seed stalk the following year after a period of rest and cold temperature. However, onions can form seed stalks prematurely (bolting) the year of seeding if they are subjected to cool temperatures after reaching the five-leaf stage. Temperatures must be below 50 degrees F for several days to induce bolting. The effect is cumulative – more bolting occurs at lower temperatures and with a longer period of cool temperatures. Some cultivars are more susceptible to cold temperatures than others. Onions grown from sets and transplants are very susceptible to bolting because they can be induced to bolt before planting.

Plant onions early in the spring so that the plants produce maximum foliage growth before bolting is initiated in mid-June. May 10 is normally the last day to plant full-season cultivars and to obtain normal maturity. Early-maturing seeded in April are ready for harvest by late August. Late-maturing onions (110 to 120 days) mature in mid- to late September. Spanish cultivars developed for the northwestern states usually do not mature in Michigan if grown from seed.

Types and Cultivars

Onions may be classified in several ways: by shape – flat, round or globe; by color – red, yellow or white; by pungency – mild (sweet or Spanish) or pungent; and by bulbing response to day length – long-, intermediate- or short-day. Most onions grown in Michigan are of the pungent yellow globe type. Only long-day cultivars can be grown from seed in Michigan. Intermediate- or short-day cultivars can be grown successfully from transplants.

Seed catalogues often give days to maturity for onion cultivars, but these are relative estimates of normal maturity. Maturity is also influenced by the date of planting, weather during the season and location in the state. In a normal year, early-maturing onions (90 to 100 days) that are

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Produced by Outreach Communications on recycled paper with vegetable-based inks.
cultivars can be seeded as late as May 20, but size and yields may be reduced. Onions initiate bulbing in response to day length. Long-day cultivars require at least 14 hours of daylight (10-hour dark period) to initiate bulbing; some require a longer period of daylight. Onion seeds germinate at temperatures above 45 degrees F, but optimum germination occurs at 75 degrees F. Optimum foliar growth occurs at 65 to 68 degrees F. Onion seedlings can tolerate light frosts (28 degrees F) but may be killed by colder temperatures. Onions grow slowly in cold, wet soils.

Onions do not tolerate extremely high temperatures well. Growth rate declines when temperatures exceed 90 degrees F for several days. High temperature hastens maturity if it occurs and lingers late in the growing season. This may result in smaller bulbs and reduced total yields. Hot, humid conditions also are conducive to foliar disease development, which may reduce bulb growth. Because of their limited root system, onions require a constant supply of water throughout the growing season. Deep mud soils with a high water table may produce a good crop of onions without irrigation, but most land needs irrigation to produce profitable yields. If rain is inadequate, supply 1 inch of water per week until July 1 and 1.5 inches per week until the bulb is in fall over. Dry weather or tops fall over will help onions mature faster, resulting in better quality onions.

Soil Requirements and Field Preparation Most onions produced in Michigan are grown on muck soils. Deep muck soils with a high water table may produce a good crop of onions without irrigation, but most land needs irrigation to produce profitable yields. If rain is inadequate, supply 1 inch of water per week until July 1 and 1.5 inches per week until the bulb is in fall over. Dry weather or tops fall over will help onions mature faster, resulting in better quality onions.

Interplanted Cover Crops Most seeded onions in Michigan are interplanted with a small grain, which serves as a nurse crop until the onions are well established. The small grain then is killed with a herbicide.

Barley is the most suitable small grain for interplanting because of its rapid emergence and upright growth habit. Broadcast 0.8 to 1.0 bushel of barley either shortly before planting or at planting. The small grain seed should be mounted on the front of the drill so that soil moved by the seeder will cover the grain seeds. The small grain should be killed with a granicide when it is 6 to 6 inches tall. It will slow the crop and provide protection for 2 to 3 weeks.

Planting on Raised Beds

Land subject to standing water may be more productive if onions are planted on raised beds. Form beds with a passable shaper mounted on the drill in front of the seed unit. Beds 4 to 6 inches high will raise the plants sufficiently to avoid being covered by water in all but the most severe situations.

Seed Treatment Before Planting

Smut is a serious disease of onions that is best controlled by treating the seed with a fungicide. Seed can be ordered with the fungicide included in a thin coating on the seed or in the pellet of pelleted seed. Fungicides may reduce germination over time. An insecticide for maggot control also may be included in the coating.

Fertilizer Requirements

Maintain a pH of 5.3 to 6.5 on muck soil and 6.2 to 6.8 on mineral soils. If the pH falls below these levels, add lime. Spots with very low pH often occur in shallow or sandy muck soils. Onions growing on these spots appear yellow and small compared with those in the rest of the field because of reduced availability of phosphorus and potassium and possible manganese toxicity. Sample these spots separately from the rest of the field when testing soil pH and apply lime as necessary to raise the pH.

Onions require high soil nutrient levels to attain maximum yields. Where onions will be grown on a regular schedule, it is wise to build up soil nutrient levels so that moderate amounts of fertilizer can be added each year. Maintain a phosphorus (P₂O₅) level of 120 to 150 lb/acre and a potassium (K₂O) level of 500 to 350 lb/acre. Add additional fertilizer on the basis of a complete soil test. Test soil every 2 years.

low halos. The spots often are confused with herbicide injury, which does not have the halos around the spots. The symptom varies from very large portions of leaves, which turn yellow and die within a week. Rainy weather causes more leaf blighting. Spores are produced after 72 hours of high humidity and moderate temperatures—averaging 78 degrees F or less. Infections occur following 8 or more hours of leaf wetness. Spray onions with a foliar fungicide on a 7- to 10-day schedule to control Botrytis blight.

Downy mildew (Peronospora destructor) occurs about midseason. Lesions 1/4 to 1/2 inch in diameter appear on mature leaves. A white to purple-colored mold develops on otherwise healthy-looking leaves as the fungus forms the spores that spread the disease. The mold is obvious in early morning when plants are wet with dew but often dries up during the heat of the day. Infected leaves dry up quickly and die after spores have formed. The disease is most prevalent during cool, wet weather with consistently high humidities at night of 80 percent or more for 6 or more hours. To avoid downy mildew, apply a foliar fungicide on a 7- to 10-day schedule as soon as foliar symptoms appear.

Purple blotch (Altemaria porri) is a fungus that is present in many Michigan fields. It often is confused with downy mildew because the symptoms are quite similar. Symptoms appear as small, water-soaked spots on leaves, which expand and turn brown and dark purple. The spots are covered with a brown mold in early morning. Affected leaves die and break off. Purple blotch spreads during warm weather (lows in the 60s and 70s and highs in the 80s and 90s) and humidity of 70 to 100 percent. Purple blotch can be controlled by applications of foliar fungicides.

Fusarium basal rot (Fusarium oxysporum f. sp. cecapii) is a problem in some fields in Michigan. The fungus lives in the soil for many years. It enters the bulb at the base through root tips or injuries caused by other organisms. Plants infected early in the season turn yellow and wilt. Bulbs infected later may appear normal and firm at harvest, but inner scales rot at the base of the bulb. The rot tends to be firm and dry. The disease progresses in storage. The outer scale of infected bulbs often appears slightly darker brown than normal.

Fusarium basal rot may be more severe in poorly drained fields. There is no chemical control. Resist cultivars are available and should be used in infested fields. Where possible, move down individual scales into the bulbs. The disease progresses during rainy weather. If dry weather returns, disease progression may be slowed and bulbs may appear normal. The infected scales may dry up. However, the rot will not be fatal in individual scales, especially in storage, causing soft, smelly-mouldy bulbs.

Some cultivars appear to be more susceptible than others. Spanish onions developed for the dry areas of the western United States are especially susceptible when grown in humid areas such as the lower peninsula of Michigan. To avoid the problem, control foliar diseases with fungicides and do not plant cultivars that are known to be susceptible. There is no chemi- cal treatment available to stop the bacteria once they are established in the plants.

The fungus is specific to members of the onion family and persists in the soil for a long time. It appears to be worse in poorly drained fields. Plant to cover large portions of leaves, which turn yellow and die within a week. Rainy weather causes more leaf blighting. Spores are produced after 72 hours of high humidity and moderate temperatures—averaging 78 degrees F or less. Infections occur following 8 or more hours of leaf wetness. Spray onions with a foliar fungicide on a 7- to 10-day schedule to control Botrytis blight.

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Bacterial soft rot (Erwinia carotovora and Pseudomonas spp.) enters bulbs through the neck during the growing season. It often begins in leaves infected with other organ-
sprayer. High spray volume and pressure will increase cover- age of new growth, where thrips and damage are con- centrated. Control may need to be repeated after 7 to 10 days to control thrips larvae hatching from eggs or adults emerging from pupation in the soil. Check onions under heavy rains – rain is a major mortality factor and treatment may not be necessary.

Onion thrips can develop resistance to frequently used insecticides. Resistance problems may be different at dif- ferent locations, depending on previous history of onion production and insecticides used. To reduce resistance problems, treat only when necessary to avoid crop damage. Fewer insecticide treatments not only will reduce selection for insecticide resistance but will help conserve natural enemies of onion thrips and onion maggot.

Alternating insecticides from different chemical groups also will help reduce resistance problems. For example, Ammo (a pyrethroid) could be alternated with Lannate (a carbamate).

Consult Extension bulletin E-312 for a list of insectic-ides and their chemical groups and for specific recom- mendations for control of onion thrips.

Nematodes

Northern root-knot, root-lesion, onion blight and stubby-root nematodes are found in Michigan fields and can reduce yields. If nematode problems are suspected, have soil and root tissue tested for nematodes. (See Extension bulletin E-600, ‘Nematode Detection’) If nematodes are present in numbers above an action threshold, an appro- priate nematode management procedure will be recom- mended.

Diseases

Smut (Urocystis colchici) is a soil-borne fungus that causes black streaks in the outer bulb scales and leaves of young plants. Leaves often twist and turn yellow. The black streaks in bulbs and leaves are filled with black, dusty spores. Infected young plants usually die, but some infect- ed plants survive to develop small bulbs. Smut infection greatly reduces yields and quality. The fungus overwinters in the soil. Virtually all Michigan onion fields are infected with this disease. All seed should be treated with a fungici- cide, either before or at seeding. Crop rotation will help reduce infection levels.

Environmental monitoring equipment and software have been developed to predict onion foliar disease outbreaks.

Programs are currently available for Botrytis leaf blight, downy mildew and purple blotch. In a normal year, apply- ing fungicides according to predictor recommendations can save several sprays and reduce production costs.

Botrytis leaf blight (Botrytis aquamosa) causes small, white spots on leaves that are surrounded by light green or yel- low margins. These margins may result in larger total yields, but the percentage of onions over 2 inches in diameter will decrease.

Approximately 2 to 0.5 lb of seed are needed to plant one acre of pungent yellow onions. To determine how much seed is needed, check the number of seeds per pound and the germination rate of the seed. Then divide the desired plant population by the number of seeds per pound to determine the amount of seed required per acre. For example, if there are 100,000 onion seeds per lb and the seed has a 90 percent germination rate, each pound of seed will produce about 90,000 plants. Dividing 300,000 plants per acre by 90,000 live seeds per lb equals 2.2 lb of seed per acre.

A seeder used for sowing onions must be adjustable to be able to plant different populations. The seeder also must be able to apply insecticide and fungicide in the furrow with the seed. The onion seed in most soil 0.5 to 1 inch deep.

Dry onions also can be grown from sets. Approximately 800 lb of sets 7/8 inch or less in diameter are needed to plant 1 acre. Fertilization practices are the same as for seeded onions. Sets onions usually mature 2 to 3 weeks earlier than onion seed, so sets should be stored soon after harvest and should not be stored.
Transplanted onions
Spanish onions mature very late in the season when grown from seed in Michigan. However, they can be grown successfully from transplants. Short-day cultivars will produce large, early onions if grown from transplants that are at least 8 to 10 weeks old at transplanting. They begin to bulb about one month earlier than long-day onions in Michigan. Approximately 120,000 to 140,000 plants are needed to plant 1 acre. Plant the seedlings 3 to 4 inches apart in rows 15 to 24 inches apart with a transplanting machine. The greatest difficulty with Spanish onion production is their susceptibility to bacterial soft rot.

Plants usually are obtained from the southern United States but can be grown in the greenhouse. To have plants ready to plant in April, sow seed in mid-January. Good plants are 1/8 to 1/4 inch in diameter at the base. Trim plants to 4 to 6 inches to facilitate transplanting and to reduce dehydration of the plants in the field.

When plants arrive from the South, they should be planted as soon as possible. If they have to be stored more than two days, open the boxes and remove some plants to allow good air circulation through the boxes. Keep them cool (40 to 50 degrees F) but do not refrigerate below 40 degrees F. They should remain good for about 2 weeks. Do not plant seedlings that are brown, soft and rotten. If the leaves are dry but bulbs are still intact, they probably will grow.

Seed Storage
Onion seed loses its viability rapidly. Check each lot of seed for germination before planting to determine seeding rate. This is especially important for seed more than 1 year old.

Onion seed can be stored successfully with little loss of viability for 2 to 3 years if kept at 50 percent or lower relative humidity and 32 degrees F. If packed in air-tight containers and refrigerated, seed will last up to 10 years.

During the Growing Season
During the growing season, check onions at least weekly to monitor insects, diseases, weeds and plant nutrition. A rapid response to growth impediments will help keep onion leaves green and produce a harvestable product. If foliar diseases, thrps, nutritional deficiencies or weeds get out of control, it may be difficult to overcome their injury to the crop and yields will be depressed.

Be especially observant after heavy rains and during hot, humid weather. If heavy rains soak the soil surface, cultivate the interrow spaces to break the crust as soon as the soil surface is dry. Heavy rains also may leach out nitrogen and topdressing may be required.

Preharvest
Onions may be treated with maleic hydrazide (MH) in the field to reduce sprouting during and after storage. MH suppresses new growth in mature bulbs that have reached their normal resprouting time. MH may not prevent sprouting in short-storage cultivars or onions that are harvested before they are mature. Apply MH when onions are fully mature and leaves are still green but necks are soft and about 50 percent of the tops have fallen over. Application of MH before onions are mature results in soft, spongy bulbs. Applications after most leaves have died will not prevent sprouting. Apply 2 to 4 active ingredient MH in 30 gal water per acre when the temperature is below 80 degrees F.

Maturity
Onions are mature when they stop producing new leaves. The neck then begins to shrink and the bulbs fall over. Onion bulbs continue to grow in size and weight until leaves are dry. Maturity is controlled primarily by genetics. Some cultivars stop growing earlier than others. Other factors that influence maturity are total heat units during the season, nutrients, growing space and growing conditions. Thus, an onion cultivar that is supposed to mature in 100 days may take 120 days to fall over under adverse growing conditions.

An onion bulb neither sprouting nor rooting is considered to be dormant. An onion bulb that is mature and has ceased production of new leaves is said to be resting. If ambient conditions change to support growth, a dormant bulb may immediately produce leaves or roots. A resting bulb goes through an extended period of rest before sprouting. Long-storage cultivars have a resting period of several months. Short-storage cultivars may have a resting period as short as one month.

It is important to select cultivars that normally mature in an area. In an average year, tops should be going down on the latest cultivars by mid-September.

Rolling leaves and undercutting bulbs of onions that still have green, erect leaves are common practices to hasten maturity. These practices may help dry down the leaves and induce dormancy, but the bulbs may not be fully mature. Bulbs harvested after these preharvest treatments may sprout in storage or after removal from storage if exposed to adverse temperature or humidity.

Harvest
Onions are harvested with machines that dig the bulbs and remove the tops. The onions are dumped into bulk boxes or bulk trucks for transport from the field and into storage. Spanish onions are usually topped by hand and then placed into bulk boxes. They should not be handled or stored in bulk piles because of their soft flesh.

Curing
Onions have to be cured before storage. During curing, the outer scales and neck dry out and shrink. Curing can be accomplished by placing onions in crates exposed to ambient air of 75 to 80 degrees F for 2 to 3 weeks. Onions can be cured in storage by forcing warm (90 degrees F) through the pile for 4 to 5 days. The air should have an initial relative humidity of 60 to 70 percent. Heated, saturated air should exit the storage and not be recycled. Air volume should be at least 1.5 cubic feet per minute for each cubic foot of onions.

Storage
After curing, gradually decrease the storage temperature. Do not reduce the temperature of air in the storage that of outside air, because a few warm days will cause moisture to accumulate on the bulbs and result in discoloration and potential decay of bulbs. After curing is complete, air flow may be reduced to 0.75 cu ft/min/cu ft of bulbs. By late October, onion temperatures should be about 45 degrees F. By late November, they should be at 32 to 35 degrees F and at a relative humidity of 60 to 70 percent. To maintain uniform temperature within the onion pile and to remove moisture from upper layers, blow outside air through the storage 2 to 4 hours per day 1 to 2 days per week on cool, dry days.

For more information on onion storage, see Extension bulletin E-1409, “Temperature and Humidity Guides to Curing and Storing Onions.”

Grading and Packing
When removing onions from cold storage, allow them to warm up to 50 degrees F before packing to avoid moisture condensation on bulbs in packages. Onions can be warmed up by blowing warm air through the portion of the pile to be packed one or two days before packing, or by placing onions in crates and moving them out of the storage into a warmer area.

Michigan storage onions usually are packed in 3-, 10- or 50-lb bags for fresh market. The onions normally are packed to meet U.S. No. 1 grade standards for medium-sized storage onions: mature; fairly firm; fairly well shaped; free from decay, scars, mold, doubles, boltnecks, seed stems, splits, sprouts, frost damage, peeling, cracked fleshly scores, dirt, and insect and disease damage. Diameter should be at least 1 1/2 inches and 40 percent of a lot must be 2 inches or larger in diameter.

Individual packages in a lot may have as few as 15 percent onions over 2 inches, but the entire lot must average 40 percent over 2 inches.

Physiological Disorders
Tipburn often occurs in mid- to late summer. The upper 1 to 2 inches of mature leaves turn yellow and brown, but the rest of the leaves may remain green. In extreme conditions, all the leaves die without browning over. A field may turn from green to brown in one week, even with control of foliar diseases.

Tipburn appears to be caused by a combination of factors, including incipient maturity, dry conditions exacerbated by pink root, thrip damage, nutrient deficiency, and effects of foliar diseases such as purple blotch, Botrytis blight and downy mildew. If a large portion of foliar tissue dies, yield may be reduced. Good cultural practices and disease control and timely irrigation will help avoid tipburn. When possible, select cultivars with pink root tolerance.

Insects
Onion maggot (Delia antiqua) is the most severe pest of onions in Michigan. Photos of onion maggot larvae, pupae, adults and damage are shown in Extension bulletin E-972, “Leek and Onion Pests.” The onion maggot is adapted to cool weather and damage is most severe during years with cool, wet spring weather. Onion plant stand may be reduced to 40 to 80 percent in severe situations.

Onion maggots overwinter as pupae in the soil. Adults (1/4 inch long, brownish gray) emerge from overwintering in the early spring and lay eggs on volunteer onions and new seedlings. The first eggs are laid on the volunteers because they are larger and more attractive to the females. Early-seeded onions are more attractive than later plantings because of plant size.

The white, oval-shaped eggs often can be seen at the bases of the plants. They also are laid in cracks in the soil next to the onion plants. Larvae are white, up to 1 inch long, with no legs or discernible head region. After larvae hatch from the eggs, they feed on the onion roots and bulbs. When onion plants are small, several plants in a row can be destroyed by one onion maggot before it is fully grown and pupates in the soil under the row. Adults emerge in July and early August.

The second generation of onion maggots (eggs laid from July through early August) is much less damaging than the first generation. Onion maggot females are most attracted to previously damaged onions for egg laying. This is probably because newly hatched onion maggots are not able to penetrate the thick scales that healthy onions develop as