Aster yellows is caused by a mycoplasma carried by the aster leafhopper (*Macrosteles fascifrons*). 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 totalling less than $100 must be prepaid.)

E-312 – Control of Insects, Diseases and Nematodes on Commercial Vegetables.

E-486 – Secondary and Micronutrients for Vegetables and Field Crops.

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.

NCR-330 – North Central Weed Control Guide for Vegetable Crops.

Revision – 1:96 – 2M – LJ – SP
File 26.57

Produced by Outreach Communications on recycled paper with vegetable-based inks.

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

Commercial Vegetable Recommendations

ONIONS

Bernard H. Zandstra
Department of Horticulture

Edward J. Grafius
Department of Entomology

Melvyn L. Lacy
Department of Botany and Plant Pathology

Darryl D. Warncke
Department of Crop and Soil Sciences

Production and Use

The average yield of U.S. No. l 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.

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 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.

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 foliar growth before bulbing is initiated in mid-June. May 10 is normally the last day to plant full-season cultivars and to obtain normal maturity. Early-maturing

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 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 tops begin to fall over. Dry weather after 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 are ideal for onion production because of their good water retention, high nitrogen content, ease of nutrient management and ease of harvest. When onions are grown on sandy or marl mucks or mineral soils, more careful irrigation and fertilizer management are required.

Onion yields decrease under continuous production. Insects and diseases build up with continuous production of a single crop, and yields and quality often decline. In addition, onions return very little organic matter to the soil, causing soils in continuous production to become hard and compacted. Carrots, celery and potatoes are common rotational crops for onions. Corn, sorghum, mint or a small grain also should be included in the rotation every 3 to 5 years to add large amounts of active organic matter to the soil.

If possible, plant a rye or barley cover crop in the fall on onion land. Plow 8 to 10 inches deep shortly before sowing onions to retain as much soil moisture as possible. If the cover crop grows too vigorously, mow it before plowing. After plowing, use a roller to pack the soil to form a firm seedbed, and sow seed immediately.

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 l.0 bushel of barley either shortly before planting or at planting. The small grain seeder should be mounted in front of the onion drill so that soil moved by the seeder will cover the grain seeds.

The small grain should be killed with a graminicide when it is 5 to 6 inches tall. It will die slowly and continue to provide protection for another 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 passive shaper mounted on the onion drill in front of the seeder units. 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 fields. 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 phosphate (P_2O_5) level of 120 to 150 lb/acre and a potash (K_20) level of 300 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 spots may expand 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.

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 95 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 (*Alternaria 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. *cepa*) 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 scales of infected bulbs often appear slightly darker brown than normal.

Fusarium basal rot may be more severe in poorly drained fields. There is no chemical control. Resistant cultivars are available and should be used in infested fields. Where possible, grow other crops on badly infested fields.

White rot (*Sclerotium cepivorum*) has appeared in only a few fields in Michigan. It is a serious problem in other northern states and Canada, and there is potential for more problems in Michigan. The disease appears as yellowing and wilting of the leaves. The bulbs become soft and rotten and can be pulled from the soil easily because the roots have rotted. A white mold develops on the bulbs, and black sclerotia form in the mold and on the bulbs. The sclerotia look like grains of black soil but can be identified under a microscope.

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 breeders are working on resistant cultivars, but none are commercially available yet. Therefore, the only current solution to white rot is to grow other crops in badly infested fields.

Pink root (*Pyrenochaeta terrestris*) is a soil-borne fungus that is present in virtually all Michigan onion fields. Although it is always present, it causes serious yield reduction during hot, dry years. Roots turn bright pink and die, and new roots form throughout the season. Infected plants have 50 percent or less of the root system of healthy plants, and consequently, water and nutrient uptake are reduced. Infected plants also appear to be more susceptible to other diseases, such as Fusarium basal rot and white rot. Southern transplants often are infested with pink root, leading to severe disease in the field.

Heavily infested fields should be managed carefully with special attention given to irrigation, drainage and fertilization to obtain maximum yields. The disease does not have an adverse effect on the quality of harvested bulbs because it is confined to the roots during the growing season.

Botrytis neck rot (*Botrytis allii*) is a common disease of bulbs in storage. The organism enters the bulbs through the neck during the growing season or after harvest. The scales at the base of the neck become soft and collapse; a whitish gray mold with black sclerotia appears on the fleshy scales under the dry outer scales. The bulbs gradually soften and the inner flesh appears cooked or frozen. Soft rot may set in and the bulbs become smelly, soft and rotten. To avoid Botrytis neck rot, control foliar diseases throughout the season. Harvest onions when they are mature and necks are well dried. Leave 1 to 2 inches of neck on the onions and cure well before storage. Do not store onions harvested from wet areas. Avoid bruising bulbs during harvest.

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 organisms and moves 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 normally progresses eventually, especially in storage, causing soft, foul-smelling 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 Michigan. To avoid the problem, control foliar diseases with fungicides and do not plant cultivars that are known to be susceptible. There is no chemical treatment available to stop the bacteria once they are established in the plants.

they mature. Also, egg mortality is high because of hot soil surface temperatures during July and August – eggs are killed by temperatures of 112 degrees F or higher, and soil surface temperatures often exceed 140 degrees F. Adults of the second generation emerge in late August and September.

Third generation eggs usually are laid on cull or damaged onions left after harvest. Third generation larvae feed and grow through the fall and pupate in the soil, where they overwinter. Conditions are often ideal for the onion maggot during the fall: cool, wet weather with lots of damaged, rotting onions for food. Many pupae can be produced in the fall. These emerge as adults the next spring and attack the new onion crop.

The onion maggot has become resistant to every insecticide used to control it. It can rapidly develop insecticide resistance because it has a high reproductive rate, nearly all are exposed to insecticides, and it has the ability to resist toxic chemicals like those present in onion bulbs. Because of continuing insecticide resistance, onion maggot management must include a variety of control measures. The key controls are: treatment of the onions with an insecticide at planting to reduce stand loss, and clean harvesting and burying cull onions after harvest to reduce the increase in maggot numbers that may occur at this time. The third part of this management approach is to reduce foliar insecticide treatments to the very minimum necessary to control onion thrips. Foliar insecticides have no effect on onion maggot damage, but they kill natural enemies and increase insecticide resistance in the onion maggot. Consult Extension bulletin E-312, "Insect, Disease and Nematode Control – Commercial Vegetables," for insecticides recommended for controlling onion maggot during the first generation.

Thrips (*Thrips tabaci*) are very small (1/16 inch) cream or brown insects that feed by scraping the surface of the foliage. They feed most heavily on the new growing tips of the onions, and serious damage can turn new growth brown and reduce plant growth and yield. See Extension bulletin E-972 for photos of thrips and damage.

Thrips feed on a wide variety of crops and weeds. Eggs are laid in the plant tissue. Larvae and adults feed on plant tissue. Larvae pupate in the soil beneath the plants. Thrips multiply most quickly during hot, dry weather; heavy rainfall is one of the most important mortality factors. Thrips may overwinter on cull onions or onions in storage as well as on weeds adjacent to onion fields. They also may migrate long distances into onion fields from weeds or crops. Onion transplants, especially those brought in from southern states, should be checked carefully for onion thrips before planting.

Onion plants should be checked carefully for thrips weekly, especially during July and August, and insecticide applied if thrips numbers exceed 10 to 15 per plant. Insecticide treatment is most effective if it is applied by ground sprayer. High spray volume and pressure will increase coverage of new growth, where thrips and damage are concentrated. Treatment may need to be repeated in 5 to 7 days to control thrips larvae hatching from eggs or adults emerging from pupation in the soil. Check onions after 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 different 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 insecticides and their chemical groups and for specific recommendations for control of onion thrips.

Nematodes

Northern root-knot, root-lesion, onion bloat and stubby-root nematodes are found in Michigan onion fields and can reduce yields. If nematode problems are suspected, have soil and root tissue tested for nematodes. (See Extension bulletin E-800, "Nematode Detection.") If nematodes are present in numbers above an action threshold, an appropriate nematode management procedure will be recommended.

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 infected 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 smut. All onion seed should be treated with a fungicide, 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, applying fungicides according to predictor recommendations can save several sprays and reduce production costs.

Botrytis leaf blight (*Botrytis squamosa*) causes small, white spots on leaves that are surrounded by light green or yel-

An onion crop of 1,000 bags per acre removes about 80 lb nitrogen (N), 50 lb P_2O_5 and 80 lb K_2O from the soil. To maintain sufficient nutrient levels in the soil, add N, P_2O_5 and K_2O according to soil test results.

Fertilizer can be supplied through combinations of preplant broadcast, band application at seeding and mid-June topdress applications. Do not apply N after July 15 because this may delay maturity. Possible fertilizer combinations are:

- Broadcast and disk in 350 lb of 0-0-60 per acre (210 lb K_2O). Band 200 lb 18-46-0 or 25 gallons 10-34-0 per acre 3 inches below the seed at seeding (36 lb N and 92 lb P_20_5 or 29 lb N and 97 lb P_20_5). Topdress in mid- to late June with 250 lb of 45-0-0 or 330 lb of 34-0-0 per acre (112 lb N).
- Broadcast and disk in 400 lb of 12-24-24 and 200 lb of 0-0-60 per acre (48 lb N, 96 lb P_2O_5 and 216 lb K_2O). Topdress with 220 lb 45-0-0 or 295 lb 34-0-0 per acre (100 lb N).
- On mineral soils, in addition to the preplant broadcast and seeding time fertilizer, topdress with 155 lb of 45-0-0 or 205 lb 34-0-0 per acre in early June and again in late June.
- For green bunching onions, apply and disk in 500 lb 19-19-19 per acre or the equivalent (95 lb N, 95 lb P_2O_5, 95 lb K_2O) on both muck and mineral soils. If subsequent crops of green onions are planted on the field the same year, reduce fertilizer rates for subsequent crops to 350 lb 19-19-19 per acre.

Copper (Cu) deficiency may be a problem on new muck soil. It seldom occurs on mineral soils. Symptoms in onions are wilting and death of leaf tips and poor pigmentation of bulbs. If soil test (1M HCl) levels of Cu are below 20 ppm, apply 3 lb of actual Cu per acre (12 lb copper sulfate) in the banded fertilizer yearly until 40 lb actual Cu have been applied per acre. Onion seed should not contact Cu fertilizer. If Cu is broadcast instead of banded, increase the application rate to 10 lb actual Cu per acre per year.

Manganese (Mn) is deficient in most muck soils and many mineral soils in Michigan. Deficient onion plants are generally pale green, appearing to be deficient in N. Leaves of Mn-deficient onions also may appear droopy or wilted. The deficiency will be most obvious on muck soils with a pH above 6.0 and on mineral soils with a pH above 6.5.

To avoid Mn deficiency, apply 4 to 8 lb Mn per acre (15 to 30 lb manganese sulfate) in the banded fertilizer at seeding. Broadcast applications of Mn are not very effective. If fertilizer is not banded at seeding, apply 1 to 2 lb Mn (4 to 8 lb manganese sulfate) per acre in foliar sprays beginning when the onions have three to four true leaves. Reapply one or two times, with 10 days between applications. Include a surfactant in the solution.

Zinc (Zn) deficiency may occur in onions grown on new muck. The deficiency causes stunting, twisting and bending of leaves and yellow striping of leaf tops. On new muck, add 3 lb Zn (10 lb zinc sulfate) in the banded fertilizer per acre per year until a total of 25 lb Zn has been applied per acre. No more Zn should be needed after that unless soil test levels fall below 2 ppm (0.1 M HCl). Zn EDTA is five times more effective than Zn sulfate, so the amount used can be reduced accordingly. If Zn deficiency occurs during the growing season, apply 1/2 lb Zn per acre (1 1/2 lb zinc sulfate) as a foliar spray. Include a surfactant in the solution and apply the Zn in at least 30 gal of water per acre.

Molybdenum (Mo) deficiency may occur in onions grown on low-pH or high-iron muck soils. Symptoms are dying leaf tips and leaves wilting below the tip. The wilting and dying progresses down the leaves. Seed treatment is the most effective method of application. Mix 4 oz of sodium molybdate in 8 fl oz (1/2 pint) of water and stir until thoroughly dissolved. Pour the solution into 16 lb of onion seed in a rotating tumbler. If the deficiency occurs in a growing crop, apply 2 oz of sodium molybdate per acre in a foliar spray. Include a surfactant in the solution.

Spacing and Planting in the Field

Seeded onions

Maximum yields of pungent yellow onion bulbs over 2 inches in diameter are obtained with plant populations of about 200,000 plants per acre. Uniform spacing of plants in the field will improve bulb size and shape.

Onion populations of more than 200,000 plants per acre may result in larger total yields, but the percentage of onions over 2 inches in diameter will decrease. Approximately 2 to 2.5 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 live seeds per lb to figure the minimum 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 200,000 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. Plant onion seed in moist 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. Set onions usually mature 2 to 3 weeks earlier than seeded onions. They should be sold 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 l acre. Plant the seedlings 3 to 4 inches apart in rows 15 to 24 inches apart with a transplanter. 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 have become 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 ensure a productive harvest. If foliar diseases, thrips, 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 seal 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 lb 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 leaves fall over. Onion bulbs continue to gain 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 ambient 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 air (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 below 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/minute/cu ft of onions. 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, sunscald, doubles, bottlenecks, seedstems, splits, sprouts, frost damage, peeling, cracked fleshy scales, dirt, and insect and disease damage. Diameter should be a minimum of 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 bending over. A field may turn from green to brown in one week, even with control of most 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, yields 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, "Lettuce 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 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 1/4 inch long, with no legs or distinct 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