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ORGANIC ALLIUM PRODUCTION

HORTICULTURE PRODUCTION GUIDE

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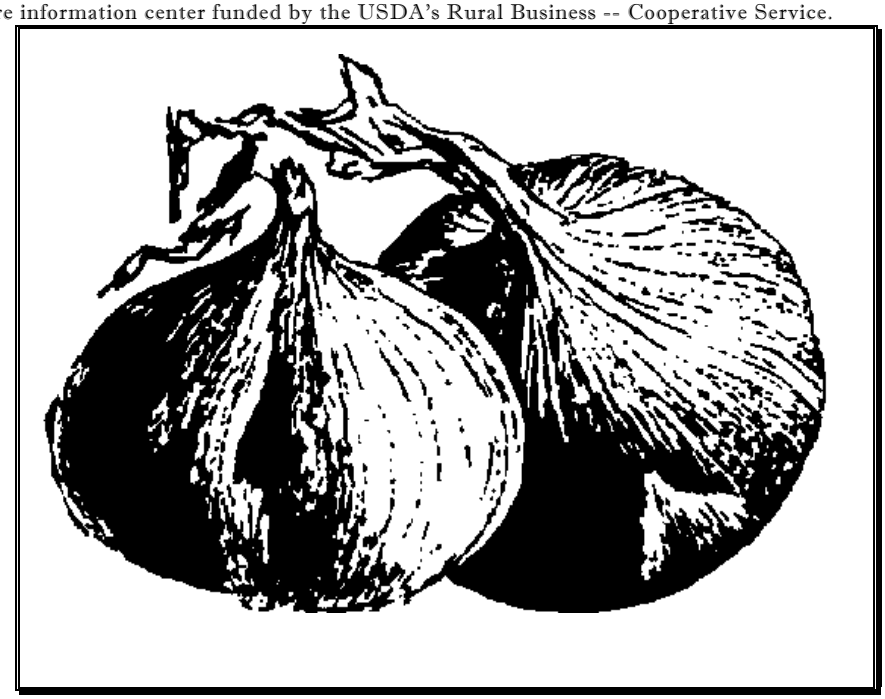

Abstract

Alliums include bulbing or dry onions, green onions, shallots, Egyptian onions, potato onions, leeks, chives and garlic. This publication discusses all alliums except for garlic, since garlic is grown and managed differently from other alliums. Information is presented on varieties, culture, soils and fertility, irrigation, integrated pest management (including weeds, insects, and diseases), harvest, postharvest, and economics. Particular attention is paid to the principal onion pests: onion maggots and onion thrips.

Introduction

Members of the genus *Allium* have been cultivated for thousands of years—for their religious significance, medicinal properties and for their pungency and characteristic flavor (1).

Content:

Most alliums are biennials or perennials, but they are commercially grown as an annual (except for seed production), and harvested primarily for their bulbs (except for chives). All alliums have certain similarities: very shallow root systems (1 foot in depth or less), sparse canopies, and frost tolerance. Most alliums are also highly sensitive to day-length.

Dry or Bulbing Onions

Dry onions are a good crop for small-scale and part-time farming operations. Multiple markets exist for growers with small acreages (.5 to 5 acres). The various colors and types of mature bulbs (red, yellow, and white) allow growers to find market niches (2). The term dry onion is used to distinguish them from green onions, which are harvested while the tops are still green and usually before a large bulb has formed.

Types of Bulbing Onions

Since bulb initiation is controlled by day-length, varieties are classified as either short day, intermediate, long day, or very long day cultivars (3). Short-day onions are very mild, soft-fleshed, and unsuitable for long-term storage. These types are grown south of 35° latitude. Intermediate-day cultivars are relatively soft-fleshed, are used primarily for the fresh trade, and are grown in areas of mild temperatures (between 32° and 38° latitude). Long-day onions are very pungent and hard. As a result, they store quite well. Long-day cultivars are usually grown for bulb production in areas above 38° latitude. Table 1 provides a brief listing of popular varieties according to day-length.

Dry bulb onion types may also be classified as either American (domestic) or European (foreign). The foreign types include Spanish and Bermuda onions. Among the Bermuda cultivars are the Grano and Granex varieties.

Planting

Three systems of planting are employed in onion production: direct seeding, the use of sets, and transplanting. Most commercial production of bulb onions is done using direct seeding, though the more expensive options of transplanting and sets may be used when timing is a critical factor. Table 2, adapted from Swaider et al. (4), provides information on seeding rates and desirable plant and row spacing.

The growing of onion sets entails direct seeding to produce very small bulbs (¼ – 1" in diameter). Production methods are largely the same as for dry bulb onions except that very dense plant spacings are used in order to obtain the small bulb size. Generally speaking, production of onion sets is considered a rather specialized industry, concentrated in a two- county area just south of Chicago and in select parts of Colorado and Oregon (4).

Table 1. Some Popular Onion Varieties Based On Day-Lengths Required for Bulbing

Short-day	Intermediate-day	Long-day
Crystal Wax	Conchise Brown	Sweet Sandwich
Granex 429	Stockton Early Red	White Ebenezer
Red Creole	Fresno White	White Sweet Spanish
Texas Grano	Rialto	Yellow Ebenezer
Red Granex	Pronto S	Yellow Sweet Spanish
Vidalia		Carmen
Walla Walla		White Lisbon
Maui		Fiesta

Table 2. Seeding Rates for Commercial Onion Production

Crop	Seed per Acres (lbs)	Plants per Foot of Row	Row Spacing (in.)
American or pungent bulbs	3-4	8-12	8-24
Sweet Spanish	1-2	3-5	12-24
Green bunching	8-12	20-56	12-18
Onion sets	40-80	solid	12-18
Pearl onions	100-120	solid	3-4 in. on multiple-row beds

When sets are planted, the smallest are most suitable for dry bulb production. Larger sets do not produce good quality bulbs and are most suitable for green onions. Optimum plant populations using sets is the same as for direct-seeded onions.

Pearl onions are a specialty crop of small bulbs grown for pickling. Standard cultivars are used; planted at very high populations.

Soils & Fertility

Proper fertility is important in onion production. Onions require fertile, well-drained, non-crusting soils, and are often produced in muck soils. A slightly acid pH in the 6.0–6.8 range is optimum. Onions require substantial amounts of nutrients. Based on a yield of 40,000 pounds of bulbs, the plants remove about 145 pounds, 25 pounds, and 155 pounds, respectively, of nitrogen, phosphorus, and potassium per acre (5).

Nutrient requirements vary with production location, variety, and soil type. Soil test recommendations should be used to determine specific application rates for individual fields. It is important to avoid overfertilization with nitrogen or phosphorus, as this will contribute to increased pest problems. Excess nitrogen also causes onions to be more susceptible to storage pathogens. Adequate potassium levels are especially important in improving bulb quality and storage life.

Organic matter in the form of either barnyard or green manure should be added to the soil. If barnyard manure is used, a typical application rate for onions is 15–20 tons per acre applied several months before planting (6). Well-composted manure is preferred because it is usually free of weed seeds and has a better nutrient balance. Composted manure is also preferred because there is less chance that the crop will take on "off-flavors" which may occur when raw wastes are applied. For more information on using manures as fertilizers, request the ATTRA publication *Manures for Vegetable Crop Production*.

Irrigation

Many farmers irrigate their onion fields. This is beneficial in several ways. Irrigation often produces larger onions, which buyers prefer. Irrigation also decreases water and heat stress, making onions more uniform and less subject to insect and disease problems. The drawbacks to irrigation, besides the obvious considerations of time and money, are that overhead irrigation may increase the risk of bacterial diseases.

Weed Management

Onions are poor competitors with weeds—due to their slow growth, shallow and fibrous root system, and the lack of an aerial canopy to shade out other vegetation. Especially in organic production, weed control in onions is crucial. No one should venture into onion production without committing time and money for good weed control. Weed control accounts for many of the costs associated with production.

Cultural methods

Weed management begins with cultural methods and strategies that help to prevent weed problems. Crop rotation suppresses weed species that establish a niche in association with particular crops. This works in several ways. For example, because the nature and the timing of cultural operations (i.e. mowing, tillage, irrigation, harvest, etc.) varies with each crop, many weed species have difficulty establishing themselves in a permanent manner when crops are rotated. In addition, the growth habit of each crop or cover crop varies in its ability to compete with weeds on their own. (Some cover crops are effective "smother crops;" others may compete allelopathically with weeds.)

Weed problems can be reduced in onions by means of a number of preventive measures. Off-season control of vegetation via tillage or use of cover crops should prevent the production and dispersal of additional weed

Farmer Profile: Anne and Eric Nordell

The Nordells farm in Pennsylvania and have developed a system for "weed-free onions" that keeps their in-the-row hand weeding labor at less than 15 hours an acre. Starting a year in advance, they use two winter cover crops and a fallow midsummer. The cover crop/fallow sequence starts with rye planted in fall. If the rye can't be planted in time or if they get a poor stand, oats are planted in the spring. These covers are cut repeatedly to create a mulch that stays on the ground right where it is cut. This keeps many weeds from germinating.

The Nordells plow under this first cover crop after it has put on the bulk of its biomass, but before summer weeds have had a chance to set seed, which for them is around the end of June. Cutting the cover crop at this time means that there's a lot of biological activity in the soil to break down residues. Plowing at this time of year also targets perennial weeds at the weakest point in their life cycle. The next step is to harrow every two to three weeks, which helps dry out perennial roots and prevents the establishment of annual weeds. As a result of this strategy, the Nordells no longer have quackgrass and only a few broadleaf weeds like pigweed and lambsquarter. Another trick up their weed-fighting sleeve is to compost horse manure before applying it to the field. This knocks out most weed seeds and doesn't stimulate weed growth like fresh manures do. They spread the composted manure during the fallow period.

Around the first or second week of August, they plant the second cover crop. The Nordells plant Canadian field peas, because they fix nitrogen and die back over winter. Winter-killed cover crops are easy to incorporate, so it's easy to make an early planting of onions in spring. Only the top two to three inches of soil is tilled, so fewer weed seeds are brought to the surface (8).

seed in the field. Using caution when moving equipment between fields reduces the likelihood that weedy rhizomes, stolons and seed may hitchhike to previously clean sites.

Pre-irrigation followed by shallow tillage as close to planting time as possible germinates and kills a large number of weeds, while minimizing the number of new seeds brought near the surface (7).

Another preventive measure for weed control is soil solarization. It is accomplished by applying clear plastic over a moist, clean-tilled seed bed, for 4–6 weeks during the hottest part of the year. Solarization is primarily useful in killing a number of pest insects and diseases, but it also kills a large number and variety of weed seeds and propagules (7). ATTRA has detailed information on soil solarization available on request.

Cultivation

Mechanical cultivation is the most commonly recognized means of non-chemical weed control in onions. It is often supplemented with hand-weeding within the row. Cultivations must be timely and should be shallow in order to reduce root damage. Cultivation technology has made numerous advances in recent years and several non-traditional cultivator designs can be found in the marketplace.

Flame weeding

Flame weeding may be an alternative to mechanical cultivation and has been studied for its suitability to onion production. Pre-plant, pre-emergent and post-emergent applications have been successful. The pre-plant application has commonly been referred to as the stale seedbed technique. After seedbed tillage is

completed, weed seeds (mostly in the upper two inches of the soil) are allowed to sprout. Assuming adequate moisture and a minimum soil temperature of 50° F (to a depth of 2 in.), this should occur within two weeks. A fine to slightly compacted seedbed will germinate a much larger number of weeds. The weeds are then "seared" with a flamer, preferably when they are between the 1st and 5th true leaf—the most vulnerable stage. The crop should then be seeded as soon as possible, with minimal soil disturbance to avoid bringing new seed to the surface. For the same reason, subsequent cultivations should be shallow (<2 in. deep) (9).

Pre-emergent flaming may also be done after seeding and prior to onion emergence. Careful monitoring is required, as onion plants are highly susceptible to damage between emergence and the four-leaf stage. While the crop can recover, yields can be reduced (10-12).

Research in Europe on post-emergent flame weeding in onions indicates that it has potential, but is rather exacting. Though onions become fairly heat resistant when they reach the four-leaf stage, they do remain sensitive to excess heat. Uniform seedbed preparation, consistent ground speed, and minimal wind during flaming are critical to successful use of this method in onions (10, 11, 13).

Weeder geese

Weeder geese were once a significant means of weed control in California, particularly on cotton. Use is again increasing as alternatives to herbicides are being pursued. Geese are voracious feeders on grasses and sedges especially when weeds are young and succulent. Geese ignore most broadleaves and are not known to feed on insects or other arthropods.

There are references in the literature to the successful use of geese in onions (14, 15). However, no specifics are provided regarding timing, population density, or possible problems. The paucity of detailed information raises concern over possible constraints. Since onions look much like grasses at emergence, there is the possibility that the birds might uproot or otherwise damage the seedlings until they learned to distinguish them from the weeds. Still worse, if geese rely solely on visual cues, they might never learn the difference, and damage would be extensive if unchecked. It is quite possible then, that weeder geese could not be used in onions until the crop is somewhat larger, well-rooted, and visually distinct from grassy weeds— though this can only be determined with any confidence via trials. Another possible concern would be compaction of the soil surface at the crop plant base, caused by the tramping of the geese. Apparently this problem has occurred with other crops on high clay/low organic matter soils.

ATTRA has more detailed information available on both flame weeding in vegetables and on weeder geese.

Insect Pest Management

Alliums may be attacked by several insect pests. The most problematic under most conditions are onion maggots and thrips.

Onion Maggots

The onion maggot (*Delia antiqua*) is a brownish-gray fly that resembles the house fly, only smaller, with longer legs. The larvae are legless, cream-colored maggots. Pupae resemble grains of wheat and are .2 –.3 in. long and chestnut-brown. Onion maggots overwinter in the pupal stage in previous onion fields, usually in the top 6 inches of soil. Adult flies emerge from their pupal cases in the spring and feed on pollen of flowering weeds.

Mature adult females begin looking for egg laying sites and fly upwind in response to onion odors produced by plant decomposition (16). Though they can fly several kilometers, many remain within a few hundred yards of their emergence sites. Once they locate an onion field they typically remain in or near the field borders. Later generations emerging from onion fields disperse very little (17).

It is common for three generations of onion maggots to occur each year. First-generation larvae cause the most economic damage, since they attack young emerging onion seedlings. Each larva can destroy 20 to 30 onion seedlings, moving from plant to plant to feed. Since females tend to lay eggs in batches, damage often occurs in clumps within the bed. The larvae usually feed for 2–3 weeks.

Attacked seedlings may wilt and disappear. Older plants in the two- to three-leaf stage wilt; the foliage becomes flaccid and discolored before drying out or beginning to decompose (16). The maggot can often be seen feeding inside the rotting stem when wilting plants are pulled and examined. Larger bulb onions initially show few above-ground symptoms. Later, however, outer leaves begin to yellow and wilt as the bulb begins to rot (16).

Second generation larvae are less damaging than the spring generation, since most onions at this point are hardened off and are much less susceptible to attack. Crops with over 12 weeks of growth are rarely attacked unless they have been injured (16).

Fall adults emerge in late summer and lay eggs, usually after harvest, on cull onions and bulbs left in the field. This is a critical time for population increase; they do especially well in cool, moist weather. The pupae from this third generation overwinter in the soil and emerge as adults the following spring.

Cultural methods

Sanitation is critical to managing onion maggot. Since damaged bulbs left in the field after harvest are the main food source for overwintering pupae, old bulbs piled near field edges should be removed or buried by mid-June before they attract egg-laying adults. Post-harvest plowing to bury and rapidly decompose crop residues is a recommended practice. Furthermore, because flies are attracted to damaged bulbs, care should be taken to avoid plant injury during field operations.

Crop rotation is useful for reducing maggot populations, especially if the crop can be grown at least one mile away from any field planted to onions the previous year (18). In areas where onion production is concentrated, crop rotation may provide only limited suppression due to the ready migration of adults between fields.

Another strategy involves delaying planting (as late as practical) to reduce the time available for spring-emerged flies to lay eggs.

Genetic resistance in onions

There are no commercial varieties resistant to early- or mid-season attack by onion maggot. Some early-maturing varieties such as 'Norstar' and 'Ruby,' however, demonstrate some tolerance to attack by the third generation of maggot larvae —most likely due to the crop hardening off earlier (19).

Biological control

Numerous beneficial organisms work to suppress the population of onion maggots in the field. These include rove beetles, of which there are both predatory and parasitic species; predaceous ground beetles and soldier beetles; robber flies and other predatory flies; predatory mites and spiders; and at least three species of wasp parasitoids, including a tiny braconid wasp, *Aphaereta pallipes*.

Natural biological control is supported by the maintenance of cover crops, hedgerows, water reservoirs and other diverse habitats. These attract and sustain populations of predatory and parasitic insects during periods when the populations of pest insects are low. By providing alternative sources of food and shelter, such habitats, often called refugia, help to provide a ready source of beneficial predators and parasites for neighboring fields when crop pests appear. ATTRA has a publication on the management of refugia, entitled *Farmscaping to Enhance Biological Control*, available on request.

Natural disease organisms also play a role in suppressing onion maggots. A fungal pathogen, *Entomophthora muscae*, is known to attack maggot larvae (20). These insect-attacking fungi can also be killed or suppressed by fungicides used to control onion diseases such as botrytis leaf blight (19). This includes those fungicides certified for use in organic production. Onion disease forecasting systems and alternative methods of disease management can help to reduce fungicide applications and enhance natural biological control.

Stimulo-Deterrent Diversion

Stimulo-Deterrent Diversion (SDD), a strategy currently being researched, may provide an organic option for maggot control. SDD uses a "pull-push" approach to controlling onion maggots (21). The "pull" or stimulant aspect uses a trap crop technique. The trap consists of adjacent planting(s) of cull onions that draw in the adult flies for egg-laying. The "push" or deterrent aspect is provided either by repellent materials applied to the main crop, or by employing varieties genetically selected for characteristics less attractive to onion maggots (22). Promising deterrent materials investigated to date include many low- and non-toxic botanicals including black pepper, dill, ginger, and capsaicin (23). The strategy targets the first generation of onion maggots, since the onion plants become progressively less susceptible to injury as they grow larger (24). The abundance of maggots that invade the trap crop also works to support a generous number of natural predators and parasites. These beneficials help keep the subsequent generations of onion maggot under control.

Exclusion barriers

Canadian research has found low-cost nylon exclusion fencing effective in restricting root maggot adults (onion maggots are a type of root maggot) from new fields (25). Research demonstrated root maggot reductions greater than 80% in early trials. Fence heights to 3.9 ft. with a slight overhang exclude most adults. *Delia antiqua* is a weak flyer, but it attempts to fly upwards when encountering an obstacle. The majority are trapped by the overhang. Combined with crop rotation, exclusion fencing might serve to overcome the ability of adult flies to migrate to new fields. Canadians found the cost of fencing comparable to that of pesticide treatments. In small-scale operations, the same sort of exclusion might also be achieved through the use of floating row covers such as Remay® (26).

Alternative pesticides

The possible use of biological pesticides such as *Beauveria bassiana* is also being investigated (27). Research done in the near future should indicate whether this or a similar material is suitable for onion maggot control. Onion maggot fly activity can be predicted using a combination of degree-day accumulation and traps to confirm their presence. (Sweep-net sampling is largely ineffective since adults may leave the field for much of the day.) For example, degree day accumulation can be used to predict emergence of the first adult generation in spring. Thereafter, trapping can be used to detect increases in egg-laying adult flies, which precede significant larval damage by at least seven days. Information such as this can be useful for scheduling spray applications. Details on degree day accumulation are generally available from Cooperative Extension in commercial onion growing regions.

Onion Thrips

There are several species of thrips that attack onions. The most common are onion thrips (*Thrips tabaci*) and western flower thrips (*Frankliniella occidentalis*). Both adults and nymphs of thrips overwinter on plants or rubbish in fields or along weedy borders (thrips have a wide host range, including cereals and broad-leaved crops) (28). Eggs are laid (nearly completely embedded) into leaves or stems and hatch in 5–10 days. About 2–4 weeks is needed for the nymphs to pass through 4 instars (growth stages) and become adults. Two of the instar stages are passed in the soil without taking food. There are generally 5–8 generations per year.

Thrips feed on onion foliage and their effect on bulb production is indirect. Feeding reduces the food production capability of the plant and interferes with transportation of foliar nutrients to the bulb. Feeding also enables various plant pathogens to gain entry, thereby increasing disease problems. Entire fields of onions can be destroyed, especially in dry seasons.

Onion plant architecture influences thrips population levels. Cultivars with flat-sided leaves and a compact growth point (where the leaves are closely compressed) protect thrips from natural enemies, weather and insecticides. Round, openly-spaced leaves reduce thrips protection (29).

The stage of growth when an infestation occurs seems to determine the extent of yield loss. It appears that early and late season infestations cause less yield reduction than those occurring in mid-season during the bulbing stage (29).

Cultural control methods

The choice of cover crops can affect the number of overwintering thrips. Wheat and rye provide excellent overwintering sites for thrips and should be avoided. Oats is a better choice, but usually requires later fall planting than rye or wheat and is not winter-hardy in many locations—constraining its use as a cover crop in northern climates (30).

Weed destruction in the field and surrounding margins can help to reduce thrips populations, since these areas serve as overwintering and re-infestation sites.

Drought stress increases onion susceptibility to thrips damage; therefore, water supply via irrigation can play a critical role in determining the amplitude of the onion plant's response to thrips damage (29).

Thrips are color-sensitive, suggesting that colored mulches may be effective in their control. To see if this tendency could be used to control thrips, Louisiana researchers conducted a study to see if aluminum-coated mulch would repel the pests (31). To make the mulch, black plastic was spray-painted in the field with aluminum paint. They found the reflective mulch repelled 33–68% of the thrips.

Genetic resistance

Some varietal resistance among sweet Spanish types is noted in the literature. It is suggested that these may be older cultivars with more open canopy growth that afford thrips less protection (19).

Biological control

Numerous beneficial organisms work to suppress thrips. These include lady beetles, minute pirate bugs, big-eyed bugs, lacewings, hover flies, predatory mites, and spiders (19). Unfortunately, these predators and parasites may be hampered by the fact that thrips feed under close-fitting leaves and down in the leaf sheaths where they are difficult to access. The use of insecticides, even those cleared for use in organic production, also work against beneficial predators and parasites and should be applied with caution.

Naturally-occurring fungal diseases can devastate thrips populations (19). Limiting the use of foliar fungicides by using forecasting systems and cultural controls helps to protect beneficial fungi and maximize this natural control mechanism.

Monitoring thrips

Monitoring to identify thrips' arrival and to determine population levels is helpful in designing an appropriate control strategy. Thrips generally migrate into a field when plants in surrounding areas begin drying, so monitoring efforts should be timed accordingly.

Thrips numbers should also be scouted in the field. The University of California recommends sampling at least five plants from four separate areas of each field. Leaves should be pulled apart and examined carefully with the assistance of a hand lens. All thrips should be counted. The numbers generated can be used to determine action thresholds for applying natural pesticides.

However, Coviello et al. (28) note that reliable treatment threshold levels have not been developed and are currently speculative. In California, a threshold of 30 thrips per plant at mid-season has been used successfully for dry bulb fresh market and drying onions, using conventional, synthetic pesticides. This number would be adjusted downward for very young plants, and upward for larger mature plants. In New York State a conservative action threshold of three thrips per leaf has been suggested; with 1 thrips per leaf for Spanish and green bunching onions (19).

When considering appropriate action threshold levels, it is important to remember that no single number will always be reliable as a guide. For example, climate factors can play a role. Hot and dry conditions favor thrips damage and cool rainy weather hinders it. In dryer years fewer thrips per leaf are tolerated by the plant before yield losses result (29). Thrips must be controlled before the onions reach the early bulbing stage so that populations do not exceed levels that can be managed (28).

Several alternative pesticides might be suggested for controlling thrips. Both sulfur and insecticidal soap have demonstrated efficacy in suppressing thrips in other crops (32). As contact materials however, their effectiveness in onions would probably be limited. The botanical pesticide, rotenone, also has a record of use in controlling thrips. Various formulations of neem such as Neemix™ and Align™, which are registered for use on food crops, might also be investigated. Also, the biological pesticide *Beauveria bassiana* appears to be effective against thrips, and new formulations might be labeled for use in onions.

For additional information on thrips management, please request ATTRA's publication entitled *Management Alternatives for Thrips on Vegetable and Flower Crops in the Field*.

Disease Management

Several fungi and bacteria attack onions. The types and severity of diseases are influenced by location, climatic factors, variety and cultural practices. Downy mildew, white rot, onion smudge, *Botrytis* leaf blight, onion smut, *Fusarium* basal rot, pink root, and neck rot are among the fungal diseases that may attack onions depending on the region of production. Bacterial soft rot, caused by the bacterium *Erwinia carotovora*, is a common bacterial disease that causes loss of onions in storage.

Cultural practices greatly influence the severity of onion diseases. To reduce disease problems, onions should be grown under optimum conditions of soil tilth, nutrition, and drainage. In some regions late planting dates should be avoided to reduce stress induced by high temperature which increase disease susceptibility. Properly maturing the crop and quick drying after harvest are also vital to disease control.

Sanitation measures such as the elimination of cull piles and the avoidance of overwintering onions or seed crops in the area will help to reduce onion disease. Exclusion of pathogens by planting only disease-free sets, seeds, or transplants is also important.

Two- to six-year crop rotations with lettuce, celery or potatoes will help reduce disease problems. Resistant varieties should also be used whenever available. Late or heavy applications of nitrogen fertilizers will increase susceptibility to neck rot and other diseases. Overwatering increases the incidence of leaf blight.

Sulfur sprays and dusts are reportedly useful in controlling downy mildew and purple blotch; and foliar sprays of seaweed extract and fish emulsion are also suggested to build disease resistance and to assist plants in regrowth following the incidence of disease (33).

Root-knot nematodes can also cause onion crop losses. Crop rotation with a poor host crop (most grains) will avoid many nematode problems. Biological controls for nematodes include the fungal parasites *Hirsutella rhossiliensis* and *Verticillium chlamydosporium*, both of which parasitize root-knot nematode larvae and eggs.

Harvest and Market Preparation

Onions are ready for harvest when the leaves begin to fall over. Bulb maturity can be accelerated by withholding irrigation water or by undercutting the root system. Bulbs for storage may be harvested when 50 percent or more of the tops have broken over, but the bulbs must cure and dry thoroughly before being stored. Bulbs intended for immediate use can be harvested when 15 to 25 percent of the tops are down (34).

Curing is recommended prior to storage. According to Daryl Richardson, a post-harvest physiologist at Oregon State University, curing allows the leaves to naturally senesce, and substances in the leaves that inhibit sprouting and promote resistance to disease-causing fungi are translocated down into the bulbs (35). Curing also allows the neck to dry and seal up, making the onions less susceptible to storage pathogens. Curing helps to develop several intact dry outer scales that limit gas exchange—both effluent and intake of moisture, oxygen and carbon dioxide. These slow down the metabolism of the onions and promote dormancy.

Onions are cured at 85–90° F with constant air movement for 4–5 days. Field curing at 75–80° F and 60–70% relative humidity can be done, but this process takes 2–3 weeks. During curing, onions must be sheltered from rain (36). Spanish types, with their soft skins, are also susceptible to sunburn and must be protected from direct sunlight during curing.

Since most onion pathogens gain access to the onion through bruises or cuts, Richardson emphasizes the need to reduce post-harvest bruising. Appropriate temperatures for storage are 32°–45°F (low) or 77°–95° (high) (3). Sweet onions may be stored at 45°–55° F. If cured and stored properly, onions can be held for six to eight months. If humidity and temperature are maintained at 40% and 37°F, respectively, some cultivars will hold for up to a year. Uniformly adequate air movement and dry conditions must be ensured. When bulbs are removed from storage, they should be conditioned for several days at 68° F and 50% relative humidity (34).

Alliums freeze solid at 31°F and will rot when thawed. Stored alliums should be inspected monthly. Remove any that have sprouted or spoiled. Otherwise, all could spoil. The larger the bulb, the greater the tendency to sprout (37).

Economics

While most information on the onion market is for conventionally grown onions, organically grown onions tend to follow the same market and pricing patterns (38).

Onions rank fourth among U.S. vegetables in per capita consumption and value after potatoes, tomatoes, and lettuce (39). Fresh market use accounts for the largest share of onion use. Most onions used in canning or freezing are fresh-market varieties, while dehydrated onion products use varieties with high solids content. Frozen onions are estimated to account for about 10% of all onions consumed. Fresh and dehydrated onions are used in a wide variety of processed foods. The continued market growth for organic processed foods means that demand for storage varieties of onions is likely to continue steady or increase (39).

Output and per capita use of the two major categories of bulb onions grown in the U.S.--storage onions and the milder spring/summer varieties--have increased during the 1990's. This reflects the changing eating patterns of Americans, who increasingly eat away from home and rely on more processed foods and prepared meals. Food manufacturers and restaurants are increasingly demanding onions and other produce in pre-prepared forms as

well, such as whole-peeled, chopped, and sliced onions. This may provide an opportunity for the grower to add value to his or her onions.

Storage types account for three-quarters of the U.S. onion market. Half of all storage onions are produced in the Northwestern states. With proper storage, onions can be stored up to 8 months, although an average of 15% of the stored crop is lost to shrinkage or defects. For most of the year, the storage onion crop sets market prices, so that prices at shipping point tend to be lowest at the peak harvest times of September and October. Prices then rise from this low and peak in April, when stored onions have all been marketed and spring onions are entering the market (39).

Onions are graded according to size and quality. A high quality pack is obtained by eliminating immature, decayed, sunburned, and mechanically injured bulbs, double bulbs, and bulbs that have started a second growth (40). Buyers usually specify minimum size of the onions they will buy. This minimum size is usually 2 inches in diameter although some will buy onions 1.5 inches in diameter. Usually onions 3 to 3.5 inches bring a premium price. Onions are usually sold in 50-pound mesh bags, although fiberboard boxes provide better protection and are becoming more popular (41).

Consumption of spring varieties of onion has increased strongly during the 1990's. Spring or sweet onions have been increasing in popularity recently and demand often exceeds supply. Wholesale market prices have been good in recent years (42). Salad bars account for much of the demand. Since spring onions do not store well, markets need to be in place well before harvest. Spring/summer onions are routinely sweeter and milder than storage onions because they have a high water and sugar content. This also makes them more susceptible to bruising. Take extra care in handling these onions. A premium is paid for large onions during harvest season.

The grower needs to investigate seasonal prices in his or her area and attempt to market the onions in periods of highest prices in order to maximize returns. Often, use of transplants rather than seed may allow the grower to begin marketing earlier in the year when prices are higher. Use of season-extension techniques or early or late varieties may also be profitable options.

The table below, developed from budget information on California organic production (43), shows the influence of yield and market price on net returns.

Costs of production for onions are highly dependent on planting methods, costs of weed control, and labor. If transplants are used, costs will be higher than if seed is used. Onions can be a very labor-intensive crop. In addition to labor required for transplanting, mechanical harvesters for storage varieties of onions have not been adapted to harvest sweet onions, so that considerable hand work is required. The grower will need to evaluate whether price advantages from earlier marketing will outweigh the cost of using transplants.

Table 3. Net Dollar Returns per Acre of Yellow Onions: Central California Coast*

	Wholesale Price Received per 50 Pound Sack											
Yield	$5.00	$6.00	$7.00	$8.00	$9.00	$10.00	$11.00	$12.00	$13.00	$14.00	$15.00	$16.00
600	-453	147	747	1347	1947	2547	3147	3747	4347	4947	5547	6147
700	-191	509	1209	1909	2609	3309	4009	4709	5409	6109	6809	7509
800	371	1171	1971	2771	3571	4371	5171	5971	6771	7571	8371	9171
850	202	1052	1902	2752	3602	4452	5302	6152	7002	7852	8702	9552
900	333	1233	2133	3033	3933	4833	5733	6633	7533	8433	9333	10233
1000	595	1595	2595	3595	4595	5595	6595	7595	8595	9595	10595	11595

*Adjusted for changes in harvest cost due to yield

Yield in 50-lb. sacks

Other Alliums

Shallots (*A. cepa aggregatum*)

Shallots can be grown all over the country, although most commercial production is done in the San Francisco Bay area and southern Louisiana. Shallots produce a cluster of bulbs somewhat like garlic. There are red-, brown-, and yellow-skinned varieties. Easily grown, they mature rapidly and will keep longer than bulbing onions, often remaining sound for 6-9 months after harvest (44).

Varieties

The variety usually found in grocery stores is either French red or Dutch yellow. French red, French gray, and Giant red shallots are larger than Dutch yellows, and they have a distinctive flavor, but are more expensive and not very good keepers. Dutch yellows are good for northern gardeners who are worried about freezing temperatures killing their sets. Brittany shallots (also known as pear or frog's leg) are larger and more elongated than other types, butnot as high-yielding (45). Because shallots have a rest period similar to onions, bulbs are commonly stored for several months before planting. Sets should be stored in a cool (32-40°F) place. They can be stored in the refrigerator, but they should be well-ventilated. See below for a list of shallot bulb suppliers.

Shallot Production

In most parts of the country, the best time to plant shallots is in fall, since spring-planted bulbs will yield smaller and fewer bulbs. However, fall planting can encourage bolting, especially in the north. Planting populations are commonly 60,000 sets/acre, roughly 200-300 lbs. Plant 4-6" apart in rows 8-12" apart. Shallot sets are almost always used, since seeds result in low yields (only one bulb produced per seed.) Seedlings are also unlike the parents (46). Sets should be placed so that the top of the bulb is even with or slightly above ground level. Fertilizer per acre recommendations are similar to onions: 100 lbs. N, 75 lbs. P, and 50 lbs. K. Additionally, 50 lbs./acre of sulfur can be helpful.

Harvest and Market Preparation

Fall-planted shallots mature in 9 months. Spring-planted bulbs mature in 3-4 months, but the clusters will be smaller. Expect to harvest 5-7 pounds of shallots for each pound planted (45). This is roughly equivalent to 8-12 shallots for every shallot set planted. Shallots are ready for harvest when the leaves begin to fall over and bulb size is over an inch in diameter. Bulb maturity can be accelerated by withholding irrigation water or by undercutting the root system. Bulbs for storage may be harvested when 50 percent or more of the tops have fallen over, but the bulbs must cure and dry thoroughly before being stored. Bulbs intended for immediate use can be harvested when 15 to 25 percent of the tops are down (5). Thick-necked bulbs should be used immediately, as they do not store well. Shallots will keep for about 8 months if stored in a cool, dry place.

Leeks (*A. ampeloprasum porrum*)

Leeks are biennials grown as annuals. They are usually started indoors in February or March and transplanted in early spring. The larger the seedling to transplant, the larger the leek to harvest. An alternative is to direct-seed and let them overwinter for a crop by late spring.

The most desirable quality in a leek is a long stem. There are a couple of ways to make longer stalks: hill soil around the plants as they grow, or plant seedlings into a trench and backfill as the plants grow.

Leeks do not bulb or go dormant in the fall but continue to grow slowly. The time of harvest is, therefore, very flexible, depending on the time of planting, market conditions, and variety of leek planted. Small leeks can be sold starting in early August, and varieties that have frost tolerance may be harvested throughout the fall and winter months.

Machine harvesting of leeks is now possible, though most leeks are lifted or dug by machine then harvested, cleaned, and packed by hand (47). The intensive use of labor in planting and harvesting makes leeks fairly expensive to produce.

Leeks are commonly trimmed to 12", bunched in threes depending on diameter, and often placed in polyethylene film bags. They are usually packaged in 10-lb cartons.

Chives (*A. schoenoprasum*)

Table 4. Leek Cultivars	
Cultivar	**Comments**
Pancho	Early, frost tolerant
Varna	Early
Titan	Early
Blue Solaise	Large, hardy, overwinters
Cortina	Late, hardy, long-stemmed
Winter Giant	Overwinters
Alaska	Late, winter-hardy
French Summer	Mild

Chives are hardy perennials that are generally used as culinary herbs rather than vegetables. There is limited commercial production of chives in the USA and little information is available on marketing (48). Chives are widely used in cooking and there may be direct marketing opportunities for chives and value-added products such as chive butters or flavored oils. Chive flowers are edible and may be marketed to upscale restaurants or other niche outlets. Another possibility could be marketing chive plants for home kitchens, possibly combined with other herbs in attractive pots.

Production of fresh culinary herbs provides opportunities to growers who develop a market niche. Large volume herbs will probably continue to come from areas of intensive production such as Florida, New Jersey and California. Overproduction of specific herbs within a limited marketplace can result in significant decreases in the wholesale market prices, so that greater opportunities for small producers may be in the development of specialized markets, rather than for the wholesale trade (49). For more information on herb production, request ATTRA's publication, *Herb Overview*.

Chives are usually started from seed. When the seedlings are a few inches tall, they should be lifted and the roots trimmed to about half an inch. Bunches of ten or twelve seedlings should be planted as one transplant, about eight inches apart in the row (50). Older chive plants can be divided, with each new clump containing 8-10 bulblets. These are then planted eight inches apart.

Chives need to be harvested continually to keep their leaves from toughening. Cut dry, put in a plastic bag, and refrigerated, they will keep for about three weeks (50). Chives can be grown under fluorescent lights for winter production.

Scallions (*A. fistulosum, A. cepa, A. ascalonicum* and their crosses)

Scallions, commonly known as green onions, spring onions, bunch onions, Welsh onions, and Japanese bunching onions, are white shank onions grown for the fresh market. Bunching onion varieties commonly grown by commercial growers include Beltsville Bunching, Beltsville White, Evergreen, Tokyo Bunching, Heshiko, White Lisbon (early, mild), Evergreen Hardy White (winters well, disease resistant), White Flash (early, mild), Kincho (late summer or fall harvest) and White Knight. Ishikura and Red Beard have dark-green leaves, white tips and roots, and bright-red stalks.

Green onions respond well to irrigation and fertilizer. The most successful growers manage both of these factors to keep onions growing rapidly. By "pushing" this crop, the green onions mature more rapidly and a grower can get more from a unit of land and reduce harvest labor by harvesting only once (51). Costs of production for green onions may be lower since they are harvested while relatively young and do not spend as much time in the field, reducing exposure to pests and disease.

For a new scallion crop, divide clumps at the end of the summer and replant. Seeds from flower heads can be planted in spring for midsummer crop or in late summer or early fall for spring harvest. Scallions can be harvested almost any time except late summer, when old tops die and new ones grow. Harvest when onions are ¼ to ½ inch in diameter at the base. There should be at least two inches of white shank. Onions are most often harvested by hand and bunched with 6-9 onions held together with rubber bands.

Potato Onions (*A. cepa aggregatum*)

"Potato onions have been found in growing trials to produce the largest weight of edible vegetables per square foot of ground of any plant except tomatoes grown on stakes or in cages" (52). Potato onions are so called because mature bulbs are flattened globes that some people think resemble potatoes. They are slightly larger than shallots and come in a wide range of colors: white (small bulbs, top flavor, good keeper), yellow (perennial, large bulbs, drought resistant), pink or red (medium bulbs, pink flesh), and purple.

Big bulbs tend to produce clusters, whereas small bulbs just get bigger. Plant bulbs about ten inches apart. In the North, plant up to 5 inches deep. In the South, use just 1 inch of soil over bulb tops. Potato onions mature in mid-summer. Harvest when the tops turn brownish-yellow. To harvest, field dry, then spread still-clustered bulbs in shaded, warm, dry, well-ventilated area on wire screens or slatted shelves for a month or two. After curing, separate dry bulbs from clusters and cut tops about 1 inch above bulb.

Egyptian Onions (*A. cepa proliferum*)

Also known as walking onion, winter onion, tree onion, and top onion, Egyptian onions produce a number of small sets at the end of their flower stalks, usually in early summer of their second year of growth. The taste of the bulb is quite astringent, so these onions are usually pickled (37). They are often grown for the leaves because the bulbs are so strong (52). Sets can be planted in late summer or early fall, since the bulbs are winter-hardy.

Egyptian onions are green at first, then mature to a reddish-brown, with each bulblet about as big as a hazelnut (50). They should be harvested after they turn a coppery color. If not harvested, the cluster of sets eventually will bend to the ground and plant itself. Egyptian onions need to be divided every couple of years because they form very large clumps.

The outer skins are tough and usually have to be peeled off (thus the common name "peelers"). McCullar's White is the most widely grown cultivar.

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Suggested Resources:

Vegetable Insect Management: with emphasis on the Midwest (1995) by Rick Foster and Brian Flood, has an excellent chapter on onions. It is available for $40 (softcover) or $54 (hardcover) plus $5 p&h from:

Meister Publishing Co.
37733 Euclid Ave.
Willoughby, Ohio 44094-5992
800-572-7740

Integrated Pest Management For Onions (1996) by Michael Hoffmann, Curtis Petzoldt, and Anne Frodsham covers insect, disease and weed pests. Of particular interest are discussions of disease forecasting systems. It is available for $17 postage paid from:

Resource Center
7 Business Technology Park
Cornell University
Ithaca, NY 14850
607-255-2080
Make checks payable to Cornell University.

Onion World is an excellent periodical published for serious onion growers and for those considering onions as an alternative crop. It is available for $15 for eight issues a year from:

Onion World
PO Box 9036
Yakima, WA 98909-0036

Web sites:

http://aesop.rutgers.edu/~farmmgmt /ne-budgets/organic/Yellow-Onion.html
Costs for production for yellow onions, per acre organic production practices for the northeastern U.S. 1996.

http://ag.arizona.edu/pubs/crops/maricopa /greenonions96.pdf
Budget for green onion production in Arizona (not organic)

http://rich.agadm.lsu.edu/
Costs of production and yield/price sensitivity for shallots (not organic), fresh-market.

http://aggie-horticulture.tamu/edu/plantanswers /publications/onions/onions.html

Suppliers of Shallots

VanBloem Gardens
Midwest Division
PO Box 603
Wayzata, MN 55391
800-683-2852
wholesaler

International Bulb Company, Inc.
PO Box 545
5 Wortendyke Ave.
Montvale, NY 07645
201-573-0363
wholesaler

Le Jardin du Gourmet
PO Box 75
St. Johnsbury Center, VT 05863
802-748-1446

Heritage Seed Company
Rt. 4, Box 187
Star City, AR 71667
501-628-4820
Offer shallots, onions, and garlic.

Shepherd's Garden Seeds
39 Irene St.
Torrington, CT 06790
860-482-3638

Ronniger's Seed Potatoes
Star Route Road 73
Moyie Springs, ID 83845
800-846-6178
French grays shipped only in fall; also offer Dutch yellow, Britany red and others

Pinetree Garden Seeds
Box 300
New Gloucester, ME 04260
207-926-3400

Richters
357 Hwy. 47
Goodwood, ON
Canada L0C 1A0
905-640-6677
Web: http://www.richters.com/
Dutch yellow shallots shipped in spring

Farmer Seed & Nursery
Division of Plantron, Inc.
Faribault, MN 55021
507-334-1623

Burpee
300 Park Ave.
Warminster, PA 18974-0001
800-333-5808

Johnny's Selected Seeds
1 Foss Hill Rd.
Albion, ME 04910
207-437-4301
French red; shipped in spring; also offer shallot seeds

Nichols Garden Nursery
1190 N. Pacific Hwy.
Albany, OR 97321
541-928-9280
French shallots shipped in fall

Jung Seed
335 S. High St.
Randolph, WI 53957
800-247-JUNG

Southern Exposure Seed Exchange
PO Box 170
Earlysville, VA 22936
804-973-4703
Web: http://www.southernexposure.com/

The electronic version of Organic Allium Production is located at:
http://www.attra.org/attra-pub/allium.html

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