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Onion Production: Planting Through Harvest

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DISCLAIMER

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Onion Production

This manual was prepared to assist USAID-Inma field staff in working with cooperating growers. It does not cover all issues or answer all questions. The USAID-Inma horticulture team or Ministry of Agriculture specialists can be consulted to answer additional questions.

Interoduction

During 2011, Iraq required 535,000 metric tons of onions per year. Onions are the fourth most consumed vegetable in Iraq after tomatoes, potatoes and cucumbers. Imports from Iran and Syria currently account for an estimated 65 percent of the onions consumed in the country.

Onions clearly represent an excellent opportunity for

crop diversification for Iraqi farmers. Farm gate prices for onions have shown an upwards trend since 2009 following changes in policies in Iran and Syria that significantly reduced subsidies on onions.

Crop Selection

There are many factors to be considered in selecting a crop for production. A farmer's previous experience producing a crop, or the availability of a contract for the purchase of a crop are certainly factors in the decision. However, there are two factors which always must be considered.

- Market demand for the period when you could reasonably expect to be able to deliver the product to the market using historical data to provide information of the normal volume and price during that period.
- The soil type, climate/micro climate, equipment, irrigation capacity and experience to be able to have a reasonable expectation that an acceptable quality product can be delivered to the market during the identified period at a unit cost, which allows the farmer to make a profit at the lower end of the accumulated range of historical price data.

If a farmer can satisfactorily answer the questions raised in these two points, he has probably identified a sustainable crop market opportunity.

Crop Rotation

Crop rotation should be a basic part of any sustainable cropping plan. It is an effective, low cost and widely used cultural practice to prevent or reduce the buildup of populations of soil-borne plant pathogens, weeds and insect pests. An effective rotation sequence includes crops from different families that are poor or non hosts of the pathogen(s) and pests of concern. In general, the longer the rotation, the better the results. A 3- to 5-year rotation is generally recommended.

However, from a practical standpoint the number of years and crops to include in a crop rotation will depend upon the availability of land, the markets, the selection of commercially viable, alternate crops suited to grow in the area, the pathogen(s), and the purpose of the rotation (pathogen prevention versus pathogen reduction).

Crop rotation along with the judicious use of appropriate herbicides is also important in controlling the buildup of different weed species.

Onions are a "fall planted-spring harvested" crop in most of Iraq and could easily follow wheat in a rotation.

Onion Notes

Onions are photoperiod sensitive, which means that varieties initiate bulb formation based on day length. Onions are classified as short day, intermediate day or long day varieties, depending upon the day length which will trigger bulb formation.

Varieties listed as short-day onions form bulbs when the day length is between 10 and 12 hours. Intermediate-day varieties form bulbs at 12 to 14 hour days. Long-day onions, on the other hand, begin to form bulbs when the day length is between 14 and 16 hours. Iraq is primarily a producer of fall planted, short day onions. Short day onions planted in spring in southern Iraq would start forming bulbs before achieving sufficient plant growth to support sizing the bulb. This would result in very small onions.

Day length varies greatly as the distance from the equator increases. Green onions are long day onions grown in an area where the day length will never be long enough to trigger bulb formation.

Most of Iraq, with the possible exception of the most northern areas of the Kurdistan region, is most suitable for growing short day onions. The optimum time for planting short day onions in Iraq is September and October, with another window of opportunity to transplant pencil-sized short-day onion shoots in January and February.

It is possible to plant intermediate day onions in the Kurdistan region in the spring, but growers would do

best to consider either fall planting of seed or transplanting in late winter or early spring.

List of Recorded and Registered Onion Varieties in Iraq

Name of Onion Varieties	Date of Record	Reference	Order
Texas Early White	25-6-2001	National Council for Register and Certified Seeds	Certified
Contesa	25-6-2001	National Council for Register and Certified Seeds	Certified
Aragon	26-7-2001	National Council for Register and Certified Seeds	Certified
Nun 2255	19-6-2002	National Council for Register and Certified Seeds	Certified
Nun 7276	22-6-2005	National Council for Register and Certified Seeds	Certified
Amcobrid	27-9-2006	National Council for Register and Certified Seeds	Certified
Zahee	27-9-2006	National Council for Register and Certified Seeds	Certified

All listed varieties are short day varieties.

Recommended Onion Production Practices for Iraq

Land Preparation

The assumption is that the land selected for onion production has been leveled and is suitable for furrow irrigation. However, sprinkler and drip irrigation are much preferred systems for the production of onions.

Steps in land preparation:

- Land should be plowed or ripped as deep as possible.
- Prepare a good seed bed, breaking up all clods with a disc and smoothing with a harrow or roller.
- If the onions are being planted behind a crop, which leaves a large amount of organic residue, the residue should be worked into the soil.
- Pre-irrigate the field. This will initiate the process of breaking down the residue and germinating weed seeds, which are present. Excessive dry matter in the soil will create problems with precision planting of the onion seed.

Pre-Plant Fertilization

After the field has been plowed, smoothed and pre-irrigated, the pre-plant fertilizer should be applied to the soil surface. A fertilizer applicator is the preferred method, but it can also be applied by hand broadcast, if necessary. One type of fertilizer applicator is the broadcast fertilizer spreader. *(Pictured at right)*

Exact fertilizer recommendations should be based on the results of soil testing and refined based on experience in the area. As a general rule, in the absence of a soil test recommendation, an application of 50 kilograms of DAP per donam should be broadcast onto the smooth soil.

Potassium (K) is essential for good onion production and it would be useful to apply K to a trial plot even if it is not shown to be deficient in the soil tests. Potassium sulfate (K2SO4) would be the preferred source of K because of the high pH of most Iraqi soils. Applying 80 kilograms of potassium sulfate per donum with the DAP should overcome any potassium deficiency.

Field Layout

The next step will be making the beds. Appropriate row spacing for onion production is 100 cm, with four lines planted on each bed. Both narrower and wider beds are used in some circumstances, but 100 cm is common. The exact spacing will depend on the adjustment possible on the equipment available. It may come to a decision based on the wheel spacing of the tractor used, and whether or not that spacing can be adjusted.

The important thing for mechanization is that both the front and rear wheels are the same track width as the furrow width. For example on 100 cm beds, the distance from the center of one tire to the center of the tire on the opposite side will be 200 cm. This allows the tractor to pass through the field without intruding on the planted crop or compacting the soil around and under the planted crop. With onions this will permit entrance of a tractor mounted sprayer to apply the herbicides necessary to keep the field free of weeds. It is extremely difficult to mechanically cultivate onions planted on multi-row beds, so the alternative to control with herbicides is hand weeding. Another alterna-

tive is planting one line of onions on a narrow bed, which can then be cultivated. However, this makes it difficult to achieve the high plant populations required for high yields. The measurement is made from the center of one ridge to the center of the adjacent ridge or from the center of one furrow to the center of the adjacent furrow.

Pre-Irrigation

Iraqi farmers have not yet learned to appreciate the value of pre-irrigating beds and knocking them down to plant into good moisture. The value comes from:

- Planting into clean conditions with good moisture, all germinated weeds having been killed. The crop seed sprouts and achieves early growth before the second flush of weeds can overtake it.
- The crop is planted onto a shaped raised bed. If crops are planted in flat fields followed by cultivating or spraying to kill the weeds, the seeds actually end up being planted down in a trench in order to be planted in good moisture.

Drip or sprinkler irrigation systems are very advantageous for germinating and producing onions. Set up the irrigation system and irrigate the field to provide moisture for germination and emergence of the seed. This will also germinate many weed seeds and make initial weed control easier. Farmers may consult irri-

gation engineers from the Ministry of Agriculture Extension Service, from irrigation equipment supply companies or from the USAID-*Inma* agribusiness program for assistance in setting up and operating irrigations systems. If the field was earlier pre-irrigated to initiate the breakdown of crop residue, it may not be necessary to pre-irrigate again with a small seeded crop like onions.

Pre-irrigation is useful for almost all crops, but it is particularly effective for large seeded crops such as corn, melons, cucumbers, potatoes and beans, which can be planted deep enough to germinate and start growth on the pre-irrigation moisture. While pre-irrigation is useful for onions in filling the soil profile with moisture, onions are a shallow planted, small seed and will require frequent, light irrigations after planting to prevent the seed drying out and ensure a good stand. Sprinkler or drip systems are much better than furrow irrigation for this type of frequent irrigation. . Many western farmers use a portable sprinkler irrigation system for seed germination and then switch to drip or furrow irrigation to finish the crop.

When the field has dried sufficiently for entrance with a tractor, the beds should be cultivated to destroy weeds. If no cultivator is available, another alternative already used by some Iraqi farmers, which could work for onion fields, is to spray a contact herbicide on the

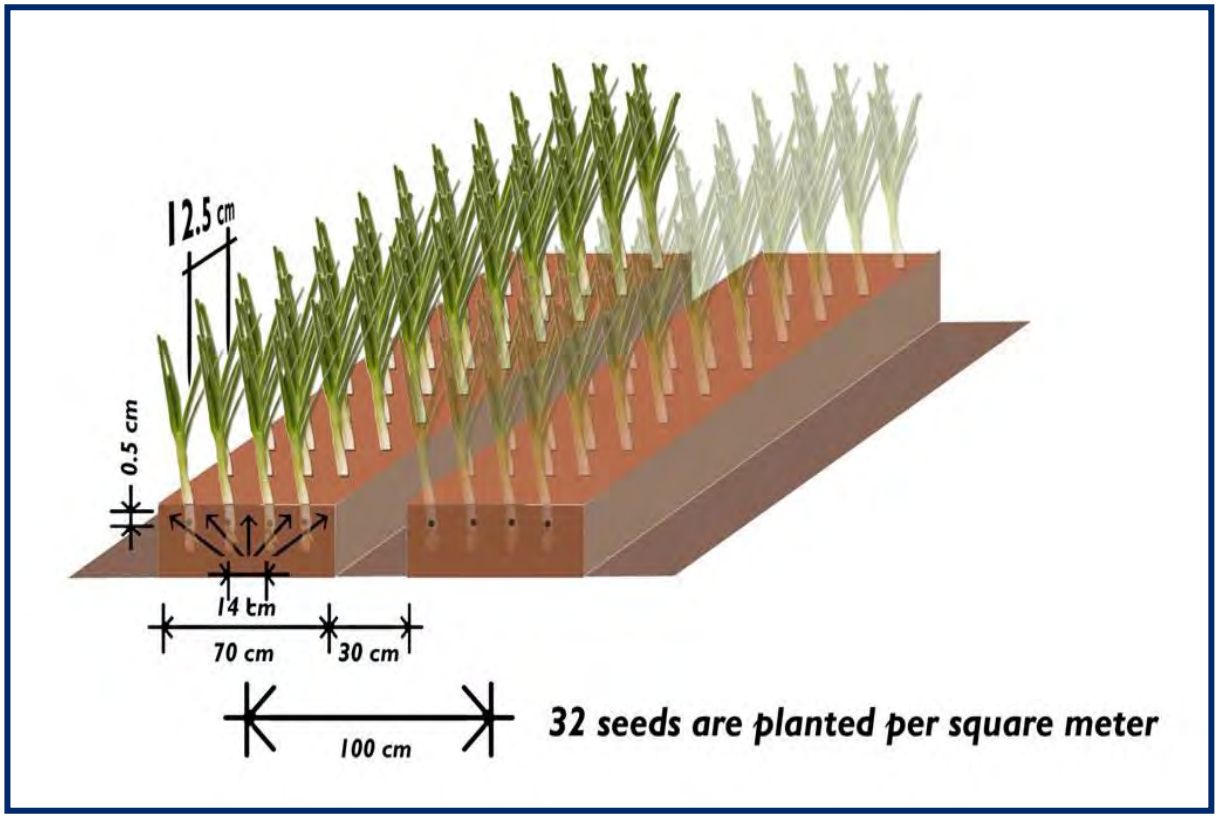
beds to burn all weed growth. Weed free beds allow germinating onions to get a head start on the weeds. Farmers should contact the Ministry of Agriculture Extension Specialist for recommendations for herbicide use on Onions.

After cultivation, onion beds will be made ready for planting by a pass of a bed shaper. This results in a standard sized, flat topped bed, which is suitable for planting with a precision planter. If a farmer does not have access to a bed shaper, a heavy pipe can be drug behind the tractor to flatten ridge tops. The height of the remaining bed can be somewhat controlled by lengthening or shortening the chains or ropes connecting the pipe to the tractor.

Seedling Establishment

There are two methods employed to establish short day onion plantings.

Onion Planting Diagram



- **Direct seeding**

  Direct seeding should take place in late September to late October in Iraq. A precision planter is recommended. Dependent on the specifications of the planter, it should be possible to plant four lines on each 100 cm bed. Planters are available to plant two, four or six rows on the bed. A measurement of 100 cm from bed center to bed center should result in a bed, after shaping, with a 70 cm wide bed top and a 30 cm wide furrow on each side of the

bed. This provides 14 cm between each line of onions on the bed and 14 cm between the outside two lines and the edge of the bed. The precision planter should be adjusted to drop a seed every 12.5 cm in each line. This is eight seeds per meter per line or a total of 32 seeds per running bed meter. This spacing will result in 80,000 seeds / plants per donum assuming a 100 percent stand.

One of the possible dangers of direct seeding, but is even more likely in transplanting short day onions too early, is having the onions bolt and go into the flowering stage. Because an onion is a bi-annual, it normally takes two years to go to seed. However, this process can be altered by low temperatures at certain growth stages, the shock of transplanting, or both. Flowering or bolting can be controlled by planting the right seed variety at the right time.

- **Transplanting**

  Transplanting requires that plants be started in a hot bed or in starter flats about a month before planting in the field. The exact timing for transplanting will be dependent on temperatures where the transplants are being produced.

  Removal from the transplant production bed and transplanting shocks the onion into a short dormant like state, Later, if the plant has at least six leaves

and experiences an extended period of cooling temperatures, it can go dormant a second time. As the temperature rises, the onion tries to start growing again, marking the beginning of its final season, which initiates flowering. This flower formation is called *bolting* or *vernalization*, and it is how seed is produced.

The possibility for bolting can be reduced by ensuring that the onion plants go into the cold weather

around the four leaf stage. This is true for both direct seeding and transplanting and controlled by date of planting and/or transplanting.

It is also possible to start the plants in a greenhouse and have them ready for transplanting in the late winter, or January in southern Iraq. Pencil sized plants transplanted in January should reduce the possibility of bolting. There are also varietal differences and some varieties are much more prone to bolt than others.
If onions are transplanted, it is recommend the same bed and spacing as recommended above for direct seeding. If drip tape is used under black plastic, onions can be transplanted through plastic mulch, which will greatly reduce weed competition problems and water usage. *(See photo above)*

Onions either direct seeded or transplanted require frequent irrigation until either the seed is germinated and emerged or until the transplanted shoot has taken root. Crusting in soils with substantial clay content can be a problem in direct seeded onions. The small onion seedling doesn't have enough size and strength to break through the crust. Frequent, light irrigations will keep the crust soft. Sprinklers or drip irrigation are much better than furrow irrigation for starting onions.

Weed Control

Mechanical cultivation of multiple row beds of onions is nearly impossible. There are four ways to ensure a weed free crop.

- For direct seeded onions the use of herbicide is probably the best solution. There are a number of materials registered for onions. USAID-*Inma* is restricted to recommending only materials listed in the project "Pesticide Evaluation Report and Safe Use Action Plan" (PERSUAP). No onion herbicides are listed, thus growers should consult their local Agriculture Extension Specialist or input supply dealer for recommendations of herbicides registered for onions in Iraq and application methods.
- The alternative to herbicide application is hand weeding.
- As mentioned above, onions can also be planted one line to a bed and cultivated mechanically, but the very narrow beds necessary to achieve the recommended plant population are very difficult to mechanize.
- For transplanted onions, use of plastic mulch with drip tape is probably the best solution for weed control.

This photo shows 4 lines of onions on a bed treated with herbicide for weed control

Onion Irrigation

Onions are a shallow-rooted crop with roots concentrated in the upper 20 cm of soil depth. Managing the timing and amount of applied irrigation water is critical to achieve optimum yields and quality. Onions must be kept growing with reasonably constant soil moisture.

The crop is most sensitive to water deficit during the yield formation period, particularly during the period of rapid bulb growth. Over-irrigation leads to reduced growth.

Onions in Iraq have been traditionally grown with furrow irrigation. The superior efficiency of water application provided by drip irrigation allows precise irrigation management than cannot be obtained with furrow irrigation. However, it is quite common for Iraqi growers to utilize sprinklers for germination. Sprinklers reduce the amount of water required and reduce the potential for salts to enter the seed row and cause emergence problems. Sprinklers can be used for the entire crop season, but there is some concern that wetting the foliage during late season causes greater incidence of foliage diseases and a subsequent increase in bulb disorders.

To be fully productive, onion irrigation requirements in Iraq are shown in the following table:

Province	Province	Crop Water Requirements (mm/year)		Irrigation Requirements (mm/year)	
North*	Sulaymaniyah	718		572	
	Erbil	967		907	
	Dahuk	722		653	
	Ninawa	897		803	
	Kirkuk	973		865	
		First planting	Second planting	First planting	Second planting
Center**	Diyala	700	272	621	261
	Baghdad	874	308	853	297
	Anbar	768	245	754	234
		Transplanted 1 March	Direct seeding in September	Transplanted 1 March	Direct seeding in September
South***	Najaf	661	261	653	261
	Diwaniyah	573	226	559	223
	Muthanna	587	222	581	210
	Dhi Qar	610	252	597	251
	Maysan	486	205	454	192
	Basrah	567	215	552	206

** From 21 February to 31 July*
*** From 1 February to 30 June and from 23 September to 23 December*
**** From 15 January to 1 June and from 7 October to 23 December*

Generally, more water is required to leach salts and to compensate for irriga-tion inefficiencies, especially in Iraq where water quality is a problem. For that reason, the leaching requirement must be determined.

Frequency of irrigation is dependent on the water holding capacity of the soil, climatic factors, such as temperature, wind, humidity and day length, and the permissible soil water depletion. In the case of onion a soil water depletion level of 30 percent of the total available soil water has been used. Based on these characteristics, irrigation calendars showing the frequency of irrigation as well as the irrigation times could be prepared as a simple, valuable tool for farmers.

In order to adjust the irrigation times and irrigation frequencies, monitoring soil moisture is helpful. Many sensors are available for monitoring soil moisture. The USAID-*Inma* program uses tensiometers and watermark electrical resistance blocks to record readings of soil moisture tension, which is a measure of the strength with which water is held by the soil. Drier

soil has a higher soil moisture tension.
Water quality is a critical factor in onion production. Excessively high soluble salts in the irrigation water slow the rate of seed germination, delay stand establishment, and adversely affect plant growth rates and yields. Onion is sensitive to soil salinity.

Onion Yield Decrease at ECe (soil salinity) Values

ECe Value	Percent of Decreased Yield
ECe 1.2 dS/m	0%
ECe 1.8 dS/m	10%
ECe 2.8 dS/m	25%
ECe 4.3 dS/m	50%
ECe 7.5dS/m	100%

Disease and Pest Control

Diseases that are common in Iraq and desert climates include, but are not limited to:

Onion Bacterial Soft Rot

Pathogens: *Erwinia carotovora* ssp. *carotovora, E. chrysanthemi, Pseudomonas gladioli,* and *Enterobacter cloacae*

Symptoms

Bacterial soft rots are characterized by softening and water soaking of one or more of the inner fleshy

scales of the bulb. Affected tissue is yellow initially, turning brown as the disease progresses lengthwise in the bulb. The neck of infected bulbs may be soft when pressed. These organisms generally appear just before or at the time of harvest or in storage.

Comments on the Diseases

Bacterial soft rots are primarily a problem on onions, but not garlic. Free water is essential for entry and spread of the bacteria. Wounds and senescent (old) leaves are the means by which bacteria gain entrance into the bulb. The pathogens are soil borne and may be spread in irrigation water.

Management
Cultural Control

Avoid overhead irrigation once onions start to form bulbs (bulbing occurs about the time the bulb is twice the diameter of the neck). Harvest only after onion tops are well matured. Provide for quick drying following topping, especially if temperatures are high.

Onion Black Mold

Pathogen: *Aspergillus niger*

Symptoms

Black mold occurs on both onions and garlic. The fungus is first evident at the top or sides of the bulb where disease or injury has caused an opening in the skin. The fungus develops between dry, dead outer scales and the first inner fleshy scales of the bulb. Invaded scales initially become water soaked. Under dry conditions diseased scales dry and shrivel, and black masses of spores are visible between outer scales. Diseased scales may also be invaded by soft rot bacteria, causing the whole bulb to deteriorate into a watery soft rot.

Comments on the Disease

Black mold occurs most commonly where onions or garlic are grown under warm dry conditions such as the desert areas of Iraq. It is more of a concern in onion crops than in garlic. The fungus survives on decaying organic matter such as plant debris.

Management

There are no chemicals for the direct control of black mold. Research indicates that a good fungicide control program for foliage diseases will reduce the incidence of black mold. Storage and transit temperatures below 12.8°C and as low as 0.6°C are recommended to suppress black mold development. Handling of bulbs to avoid bruising also reduces injury and invasion sites for the fungus.

Onion Botrytis Neck and Bulb Rot
Pathogen: *Botrytis allii*

Symptoms

In onion, Botrytis bulb rot generally appears during storage, although infection originates in the field. Initial symptoms usually begin at the neck, where affected tissue softens, becomes water soaked and turns brown. In a humid atmosphere, a gray felt-like growth appears on rotting scales and mycelia may develop between scales. Sclerotia, (a compact mass of hardened mycelium that remains dormant until a favorable opportunity for growth occurs) may eventually develop

in the neck and sometimes between scales. In garlic, symptoms appear either in the field towards the end of the season or during storage. Plants infected in the field may be stunted with dead and dying outer leaves. Affected tissue is initially water soaked but later turns dry and necrotic (dead). Sclerotia form in the neck or adhere to the rotten outer scales of the bulb. In both onion and garlic, initial infections may be present but symptoms develop only when leaves senesce and become necrotic.

Comments on the Disease

Bulb rot affects garlic, onions, leeks and shallots. The fungus persists on dead onions and garlic tissue and for long periods as sclerotia in the soil. The sclerotia germinate in moist weather and produce airborne conidia (an asexually produced fungal spore), which land on tissue, germinate and infect when conditions are favorable. The greatest incidence of infection occurs when the bulbs are cool (10° to 24°C) and moist weather prevails. The fungus is associated with garlic and onions wherever they are grown and is a common colonizer of senescent tissue.

Management

During the growing season, minimize damage to bulbs caused by insects and diseases. Avoid heavy or late applications of nitrogen fertilizer. Harvest onions and garlic only when the crop is mature and necks are well

cured. Handle the crop with a minimum of bruising or wounding. Avoid late-season irrigation to allow the tissue to dry before harvest. The neck tissue must be well-cured before the crop is stored. Healthy onions that are properly stored are seldom affected. Store bulbs at temperatures of 5°C, or less, with low relative humidity and good circulation.

Onion Downy Mildew

Pathogen: *Peronospora destructor*

Symptoms

Downy mildew can infect both onions and garlic. The first evidence of disease is a fine, furry, grayish white to purple growth on the surface of older leaves. Leaf tissue under the growth becomes pale green, then yellow,

and finally collapses. Large, yellowish, circular clumps of infected plants, a half meter or wider in diameter, may be the first symptom noticed in the field. The yellowing patterns often enlarge in the direction of prevailing winds.

Comments on the Disease

Downy mildew can develop from an initial infection by airborne spores into an epidemic very quickly if humidity and temperature conditions (1.5 to 7 hours of wet leaves and 6° to 27°C) are favorable. Spores can travel long distances in moist air, but are quickly killed by dry conditions. Initial sources of disease can be infected bulbs, sets, seeds, and plant debris.

Management

Cultural Control

Use disease-free bulbs, sets, and seed. Use a 3-year rotation away from *Allium* crops (onion, leek and garlic) in fields where the disease has occurred. Destroy volunteer *Allium* plants in and around the field and buildings. Locate onion fields where there is good air movement to promote rapid drying of foliage. Currently, there are a few red onion cultivars that are resistant to downy mildew.

Chemical Control

Spray fungicides at the first sign of disease. Fungicides may be applied on a 7-day schedule, if necessary. For

all fungicides, thorough coverage of foliage is important in the control of downy mildew.

Onion Sour Skin

Pathogen: *Pseudomonas (Burkholderia) cepacia*

Symptoms

Individual leaves affected by sour skin wilt and die back. Internally, leaves develop a soft, watery rot. The fleshy scales associated with infected leaves rot to form a tan colored slimy ring in the bulb. Adjacent rings may re-

main healthy. The neck of infected bulbs is soft when pressed.

Comments on the Diseases

Sour skin occurs on both onion and garlic, but usually is only a concern on onion. The pathogen, which survives in the soil, is splashed onto leaves and into the neck of the onion during rain or overhead irrigation. The bacteria gain entrance through wounds and water soaked tissue. Once in a leaf, bacteria continue to grow down the blade into the bulb. Warm weather favors disease development; optimum temperatures for disease development are more than 30°C.

Management

Cultural Control

Switch from sprinkler to furrow irrigation once onions start to form bulbs (bulbing occurs about the time the bulb is twice the diameter of the neck). Make sure onion tops are well matured before harvesting. Provide for quick drying following topping, especially if temperatures are high.

Onion and Garlic Basal Rot

Pathogen: *Fusarium oxysporum*

Symptoms

Plants affected by basal rot show progressive yellowing and dieback from the tips of leaves. Affected roots are

dark brown to dark pink. A white fungal growth is sometimes evident at the base of infected bulbs. When an infected bulb is cut vertically, a brown discoloration of the stem plate tissue is apparent. Later, the stem plate tissue becomes pitted and shows a dry rot. Under dry conditions, the stem plate and dry outer scales crack open. Basal rot can continue in storage.

Comments on the Disease

The fungus survives indefinitely in soil. Infection occurs through wounds or in the vicinity of old root scars at the base of the bulb. The disease is favored by soil temperatures in the range of 14° to 30°C, with optimum temperatures being 26° to 28°C. Basal rot is

more prevalent in transplanted onions than in direct-seeded onions.

Management

Cultural Control

Avoid fields with a history of basal rot problems and rotate out of onions, leeks and garlic for three to four years. Control soil insects and foliage diseases. Cure onions properly before storage. Store at cool temperatures since infection is favored by warm conditions.

Onion and Garlic Pink Root

Pathogen: *Phoma terrestris*

Symptoms

The most striking symptom of pink root is, as the name indicates, pink roots. Infected roots first turn light pink, then darken through red and purple, shrivel, turn black, and die. The pinkish red discoloration may extend up into the scales of the bulb. New roots also may become infected. If infection continues, plants become stunted. The disease seldom results in plant death. Infection is confined to roots and outer scales of the bulb. Many weak *Fusarium* species can also cause pink roots, particularly on old roots. Diagnosis of pink root can be accurately accomplished only on actively growing plants.

Comments on the Disease

Pink root is primarily a problem on onion; garlic is infected by the pink root organism, but the disease rarely occurs at an economically important level. The fungus is a common soil inhabitant that penetrates onion roots directly; wounds are not necessary for infection, but weak plants are more susceptible. The pathogen can persist in soil indefinitely; the longer onions are grown in the field, the more destructive the disease becomes. The fungus can be spread in water and on dirty equipment. Optimum temperatures for disease development are 24° to 30°C.

Management

Prevention and control include avoiding repeated cropping of onion on the same soil, use of resistant va-

rieties, good soil management and fertility, control of insects and other diseases to maintain healthy plants, and pre-plant soil fumigation. Because so many crops are hosts of the pathogen, rotation is not an effective control, but long-term rotations out of onion for five years or more are recommended because each crop of onions increases disease incidence. Planting onions after cereals can also be hazardous because the inoculum potential generally becomes greater with cereals than with onions.

Disease-resistant varieties are available, but many popular varieties do not have this characteristic; furthermore, many resistant varieties are resistant in some locations but not in others, depending on which strains of the fungus are present. Fumigation can be effective against some strains of the fungus but is not effective against many of the more virulent strains. It is also not always economical unless a high value seed crop is being grown. Solarization has proven effective in areas where onions are planted in fall after a summer fallow period.

Farmers should consult the Agriculture Extension Specialist for recommended fumigants.

This list is not all inclusive for potential onion diseases in Iraq. Contact the Ministry of Agriculture Extension Specialist or USAID-*Inma* field staff for assistance in identification of other onion diseases.

Insect Pests which may be economically damaging in Iraq include, but are not limited to:

Onion Bulb Mites

Scientific names: *Rhizoglyphus* spp., *Tyrophagus* spp.

Description of the Pest

Bulb mites are shiny, creamy white, bulbous-appearing mites that range in size from 0.5 to 1 mm long. They have four pairs of short brown legs and look like tiny pearls with legs. They generally occur in clusters inhabiting damaged areas under the root plate of onion bulbs or garlic cloves. They have a wide host range, feed on many kinds of bulbs, roots, and tubers, and can infest bulbs in storage or in the field. Bulb mites can survive on decaying vegetation in the field until it is completely decomposed.

Damage

Bulb mites damage bulbs by penetrating the outer layer of tissue and allowing rotting organisms to gain entry. This pest is most damaging when plant growth is slowed by cool, wet weather. Bulb mites can reduce plant stands, stunt plant growth, and promote rot of bulbs in storage. On seeded onions, they can cut off the radicle before the plant becomes established.

Management
Cultural Control
Rapid rotation, from one crop to the next, fosters survival of mites on the leftover vegetation in the soil from the previous crop. Decaying cole crops, especially cauliflower, may harbor very high bulb mite populations. Fallow fields allow complete decomposition of organic matter; this reduces field populations of the mite. Avoid planting successive onion or garlic crops. Flood irrigation or heavy rains during the winter may reduce mite levels in the soil.

Monitoring and Management Decisions
No specific monitoring methods are available. Use a microscope to examine fragments of un-decayed vegetation in the soil or volunteer onions or garlic for the presence of the mites.
Treatments are generally preventative and should be considered for fields that are high in vegetative matter or that have had previous bulb mite problems. No treatment thresholds exist.

Onion Maggots
Scientific names: *Seed corn maggot - Delia platura*

Description of the Pest
Adults of *Delia* species are small gray flies that are somewhat smaller than house flies. When at rest, they keep their wings folded one over the other. Larvae

are creamy white, legless maggots about 10 mm long. Microscopic examination is required to distinguish between species. The flies lay eggs in the soil surface near the germinating plants. Larvae feed on the developing seedling and, in the case of the onion maggot, on the expanding bulb. Mature larvae pupate in the soil. There are several generations per year. Maggots prefer soils heavy in organic matter where they can survive and move to seeds. Onion maggots are more restricted to cooler climates. Maggots are primarily a pest of onions and do not generally cause economic damage to garlic.

Damage

Larvae of seed corn maggots attack germinating seedlings, feeding on the developing roots and epicotyl.

Their damage is usually restricted to the very early seedling stage. Onion maggots inflict similar damage but can continue to feed on the expanding bulb during later stages of growth. This results in increased rot in bulbs held in storage.

Management

Cultural Control

Avoid planting in soils that are high in un-decomposed organic matter, such as fields just coming out of pasture or very weedy situations. In soils amended with animal manures, allow adequate time for the manure to break down before planting. Avoid planting successive rotations of onion crops. Early spring-planted crops are more likely to be damaged when the soil is too cool for rapid germination and emergence. If serious infestations are expected, wait until the soil warms up in spring, or if feasible, plant in fall while the soil is still warm. When planting, use a chain drag or similar implement behind the drill to cover the seed row.

Monitoring and Management Decisions

No specific monitoring methods have been developed. However, estimates of adult fly activity obtained from the use of yellow sticky traps have been used successfully to assist in determining the necessity and timing of treatments. The use of yellow sticky traps may also be helpful in Iraqi growing areas where onions are planted in summer or fall. Treatments for onion and

seed corn maggot are preventative and should be considered for fields that are high in organic matter or undecomposed organic material, or that have had previous maggot problems.

Onion Thrips
Scientific names: *Thrips tabaci*
Western flower thrips: *Frankliniella occidentalis*

Onion Thrips

Western Flower Thrips

Description of the Pests
Thrips are very small, slender insects that are best seen with a hand lens. Mature onion thrips are about1.3 mm long and western flower thrips are slightly larger at 1.5 mm long. The most distinctive

characteristic of thrips are two pairs of wings that are fringed with long hairs. Adults are pale yellow to light brown in color. The immature stages have the same body shape as adults but are lighter in color and are wingless. When viewed under a microscope, western flower thrips can be distinguished from onion thrips by its red eyes and 8-segmented antennae, while onion thrips' eyes are gray and its antennae are 7-segmented. Both onion thrips and western flower thrips have a very extensive range of hosts, including cereals and broadleaved crops. Both species attack onions, but onion thrips are believed to be more prevalent and injurious. They also can be a problem on garlic, but generally are not as serious a pest as they are on onion. Onion thrips thrive in hot, dry conditions and are usually more damaging in areas where these climatic conditions prevail for most of the production season.

Damage

Thrips are the most common and serious insect pest of onions, and generally are found wherever onions are grown in desert areas. High populations of thrips can reduce both yield and keeping quality of onions. Thrips are most damaging when they feed during the early bulbing stage of plant development. Scarring of leaves is a serious problem on green onions.

Thrips have rasping-sucking mouthparts and feed by rasping the surface of the leaves and sucking up the liberated plant fluid. They feed under the leaf folds and in

the protected inner leaves near the bulb. When population levels are high, thrips can also be found feeding on exposed leaf surfaces. Both adults and nymphs cause damage. When foliage is severely damaged, the entire field takes on a silvery appearance. Severe scarring also creates an entry point for foliar leaf diseases.

Management

Biological Control

Natural enemies, including predaceous mites, minute pirate bugs, and lacewings, are often found feeding on thrips. However, these beneficial insects are very susceptible to insecticide sprays, and may not be important in fields where insecticides have been used.

Cultural Control

Avoid planting onions near grain fields, if possible, because thrips numbers often build up in cereals in spring. Overhead irrigation and rainfall provide some suppression of thrips populations, but treatments are often still necessary.

Organically Acceptable Methods

Biological and cultural controls as well as sprays of the Entrust formulation of spinosad are acceptable for use on organically certified crops.

Monitoring and Management Decisions

Although thrips feeding during the early bulbing stage is the most damaging to yields, thrips must be controlled before onions reach this stage so that populations do not exceed levels that can be adequately controlled. Onions can tolerate higher thrips populations closer to harvest; however, in the case of hand-topped onions, thrips can be extremely annoying to harvest crews and treatment just before harvest may be desirable.

To make a cursory evaluation of thrips infestation levels, randomly sample leaves and evaluate thrips numbers and damage under leaf folds. A far more reliable means of evaluating thrips populations, however, is to randomly sample entire onion plants. This way leaves can be pulled apart and, using a hand lens, all the thrips on the inner leaves near the bulb can be counted as well as those under the leaf folds. Sample at least five plants from four separate areas of the field. A reliable treatment threshold has not been developed; however, a threshold of 30 thrips per plant mid-season (lower for very young plants and higher for larger mature plants) has been used successfully for dry bulb fresh market and drying onions.

For processing onions, monitor thrips by examining the entire top growth of the onion plant and counting the number of thrips. Sample 10 plants from four areas of the field. Take samples weekly and more frequently when counts exceed 20 thrips per plant. Calculate

the average number of thrips per plant on two successive sample dates. Divide the average by the number of days between samples to get the number of thrips per plant per day or thrips-days. Add up the thrips-days on the sample day to get the cumulative thrips-days (CTD) during crop growth. Research indicates that significant yield loss occurs when 500 to 600 CTD or more accumulate. This is the equivalent of 50 to 60 thrips per plant per day for 10 days, 25 to 30 thrips per plant per day for 20 days, and so on.

The marketability of green onions (those marketed fresh with the leaves attached) is severely reduced by thrips scarring; apply treatments at the first sign of thrips feeding. On onions grown for seed, thrips can reduce yield and quality of seed production during seed set, but no treatment thresholds have been established.

Harvest

As onions mature, tops begin to fall and dry, maximum yield is attained when tops are completely down and dry. Research indicates that, from the standpoint of maximum storage life (before bulb sprouting) optimum harvest would be when onion foliage is still partially (30 to 40 percent) erect. Since yields may increase 30 to 40 percent between the stage when tops begin to go down, and the leaves are fully down and dry, it is

tempting to leave onions to

cure in the field as long as possible. Therefore, the optimum time for harvest must be a balance between highest yields and reduced bulb storage quality, if there is any intent to store rather than immediately sell the onions. Furthermore excessively field-drying onions increase the risk of loss due to bald onions in storage.

Digging and Windrowing

To facilitate curing onions for harvest and storage, onion rows are undercut, lifted and windrowed for field curing. Rod-weeder diggers and knife undercutters are most common. After an appropriate interval, the undercut onions are lifted and windrowed. This may be done with tops on or tops may be removed in the windrowing operation. Onions are also commonly windrowed with tops on to protect them from sunscald. Windrows may also be mechanically "fluffed" to facilitate curing.

Topping

Early market and "overwinter" onions for immediate sale or short-term storage like those most commonly grown in Iraq are mechanically undercut and may be green-topped by hand or ma-

chine and partly cured in sacks or boxes in the field prior to packing. Since these onions are not to be stored, complete curing of necks and scales is not as important.

When these onions are intended for storage, complete curing is mandatory. Care must be exercised in handling these onions to guard against sun-scald and damage since these onions are much more succulent and have very few protective scales. When mechanically undercut and windrowed for curing, be sure onion tops provide adequate protection from sun-scald during periods of high sunlight and temperature (above 32 C).

Grading and Packing

Although damage can occur at many points from harvest to consumer, studies have shown that substantial damage occurs during grading and packing. Mechanical damage from bruises, scrapes, and cuts are cumulative but may not be evident until later. Bruised onions, in particular, may appear perfectly acceptable, with no visible evidence of damage, when they are shipped. A week or so later, however, they may be rejected when the extent of the damage becomes apparent.

In Iraq, most onions are currently field packed. Care must be taken to avoid bruising or cutting the onions as they are sacked in the field.

In a packing house, the most common form of damage is the bruising and cutting that occurs when onions strike unprotected surfaces. Losses can be reduced up to 25 percent by padding the various surfaces along the grading and packing line. The addition of 3 to 6 cm of foam to key areas will almost eliminate impact damage in those areas. Reducing the drop heights below the grader and at other points along the grading and packing line may also reduce losses.

Onions are commonly packed in mesh bags of various sizes. They may also be packed into various smaller consumer-size bags weighing from 500 grams to 5 kg and shipped in master containers. Bags, however, have

been shown to offer little protection and can subject the onions to severe damage if mishandled. The recent industry trend has been toward the use of 22 to 24 kilogram fiberboard cartons.

Onions should be transported and stored separately from other kinds of produce. Many types of fruits and vegetables will readily absorb the odor of onions. Well -dried onions also draw moisture readily from fresh vegetables.

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