Crop Profile for Onions in Wisconsin

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General Production Information

- Onions have been grown in the United States since 1625 when they were introduced by Spanish explorers. The majority of the onions grown in the United States are dry bulb onions that are allowed to mature and harvested after their tops have died.

- There are two groups of dry bulb onions: American and European. The latter includes Bermuda and Spanish onions which are primarily grown in the southern U.S. American types make up about 75% of the dry bulb crop produced in the U.S. The onions grown in Wisconsin are almost 100% fresh yellow dry bulb storage onions with a few acres of sweet Spanish transplants and cocktail onions.

- In 1996, Wisconsin harvested 1900 acres planted to dry bulb onions. The average yield per acre 315 cwt. Total production for that year was 6.29 million cwt. With a value of $10.50 per cwt.

Production Costs

The average cost of production for one acre of onions grown in 1993 was determined to be just over $4200. This information was taken from a justification for a Section 18 label submitted by E. E. Figueroa, Associate Professor at Cornell University.

Production Regions

Most of the onions grown in Wisconsin are grown in the central and south central counties of Marquette, Columbia, and Jefferson with some also being grown in Dodge, Green Lake, Waushara, Waukesha, and Racine counties as well.

Cultural Practices

The onion is a biennial monocot. The bulb is developed the first year and is the culmination of the onion plant's vegetative growth. After an extended period of cool temperatures, a seed stalk is produced. In temperate regions, this typically occurs during the second growing season. As a cool-season crop, onions grow best between 55 and 75F.

The onion bulb consists of enlarged, fleshy scales that surround a central growing point. Bulb formation is initiated by a combination of photoperiod and favorable temperature. The number of hours of daylight necessary to initiate bulbing varies from one variety to another. The rate of bulb growth is directly proportional to temperature. As the bulb grows, the outer leaves become dry and scaly while the inner leaves thicken and become fleshy. The final bulb size depends, to some extent, on the number of leaves formed by the plant prior to bulbing, available water and nutrients, and plant spacing.

Onions may be direct seeded in the field or transplanted as seedlings or sets. Transplants are sometimes used to improve bulb size or to avoid infection by some plant diseases but this method of crop establishment is more expensive. In Wisconsin, all commercially-grown onions are direct seeded in beds on deep, fertile soils in mid-April to early May. Onions are often grown on muck soils because of the tilth that prevents crusting which is detrimental for germinating onion seed. However, onions can be successfully grown on well-drained, non-crusting mineral soils with supplemental irrigation and fertilizer.

Once onion leaves have senesced and the necks have sealed, bulbs can be harvested. About 7 days prior to harvest, bulbs can be undercut to hasten the process. This reduces water uptake and growth. The mature onions are then lifted and the tops are cut to leave about 2 inches of neck. This ensures a tight seal after drying and curing to prevent the invasion of storage pathogens. The bulbs are then placed in windrows and harvested into trucks and cured in bulk storage with forced air and a drying temperature of 85-90F. For long-term storage, the sprout inhibitor maleic hydrazide is used.

Insect Pests

Onion Maggot (*Hylemya antiqua*) is frequently the most serious onion pest, particularly where continuous production is practiced. Onion maggots are highly host-specific to plants in the onion family. The insect overwinters as pupae in the soil associated with onion culls in the field or in onion cull piles. Adults emerge about mid-May and mate over a three day period after which they begin laying their tiny white eggs at the base of the plant. The larvae, upon emergence, crawl beneath the leaf sheath and enter the bulb. The onion maggot pupates in the soil and the subsequent generation of adults appears 3-4 weeks later. There are 3 generations of onion maggot per season. The first generation is often the largest and most damaging. The third generation attacks onions in mid-August shortly before harvest. Feeding damage at this time can lead to storage rots as onion maggots can introduce bacteria into the feeding wounds. Cool, wet weather favors this insect while hot, dry weather is detrimental to its survival. The

overwintering generation increases in cull onions left in the field at harvest.

Onion maggot larvae feed on the below-ground hypocotyl tissue of seedlings, resulting in a variety of damaging symptoms. Larval feeding may kill seedlings, therefore, poor plant stands may indicate a onion maggot problem. In larger plants, larvae may tunnel into the bulb causing plants to become flaccid and yellow.

Onion Thrips (*Thrips tabaci*)are an important annual pest of onions. Adults and nymphs overwinter on plants or debris or along weedy field edges. The females can reproduce without mating and lay eggs beneath the leaf surface. Eggs hatch after 5-10 days and nymphs are fully grown after 15 to 30 days. Development of the last two nymphal stages occurs in the soil, without feeding. After the 4th molt, adult female thrips return to the plant. There are usually 5-8 generations per year.

Thrips are often found between the leaf sheath and stem on onions where they are out of reach of insecticides and many natural control agents. Thrips primarily damage crops directly by their rasping and feeding activities, causing whitish blotches on leaves. Severe damage to onions will cause bulbs to become distorted or remain undersized. Hot, dry weather is correlated with occurrence of severe thrips problems.

Aster Leafhopper (*Mycrosteles fascifrons*)is the vector of the phytoplasma that causes aster yellows disease on numerous plant species. Adult aster leafhoppers have a very low feeding preference for onions and the nymphs will not feed on onions at all. The first aster leafhoppers that appear in spring migrate from their overwintering sites in grain fields in Louisiana and Missouri. In early summer, local populations begin to emerge and large influxes are possible.

Eggs are laid beneath the epidermis of leaves of susceptible hosts. Leafhoppers progress through five nymphal instars over 20-30 days. There are 2-5 generations per year. Only adult leafhoppers are of concern in onions.

Damage caused by the leafhopper is primarily the transmission of the aster yellows disease. Symptoms include chlorosis of the leaves, stunting and twisting of the stems and leaves, and leaf proliferation. Bulbs infected with aster yellows do not dry well and storage onions sprout prematurely and eventually rot. Since there is no control for this disease once infection has occurred, control of the vector is necessary.

Chemical Controls for Insect Pests in IPM & Resistance Management Programs

Insect management programs for the three primary insect pests of onion in the Midwest are interlinked as a result of insecticide resistance. Resistance has been documented in both onion maggot and thrips and management alternatives for individual pests must be selected which do not exacerbate resistance concerns for other species. Due to the complicated nature of onion insect control, all Wisconsin onion growers utilize an IPM approach when managing insects.

Pesticide use data was obtained from the *Biologic & Economic Assessment of Impact of Pesticide Use on Dry Bulb Onions* by Eckenrode, et. al. and represents the survey years 1989-93.

Onion Maggot

Effective IPM programs for onion maggot should include the following elements to reduce populations, avoid resistance, and achieve control:

- Rotate onion crops whenever possible to provide at least 0.5 miles of separation between new seedings and previous crops or cull piles. This may not always be possible on smaller farms.
- Reduce overwintering populations of onion maggot by removing harvest culls from the field and reduce the availability of cull piles for fall reproduction by distance separation from the crop, burying or deep piling to generate heat.
- Avoid crop damage from spraying late in the season when possible since damaged onions are attractive to onion maggot adults.
- Avoid foliar sprays for adult onion maggot control since these are generally ineffective on adult populations which move in and out of fields.
- Use a preventative soil treatment for control of first generation larvae if damage in the previous year's crop exceeded 5-10%

Soil Insecticides for Onion Maggot Larval Control

Chlorpyrifos (Lorsban 4E, Lorsban 15G)
is an organophosphate insecticide that is registered as a soil insecticide for control of first generation onion maggot larvae. The 4E formulation which is use most frequently, is applied as a drench in the seed furrow at planting at the rate of 1.1 fluid ounce per 1000 linear feet of row at an 18-inch row spacing. A minimum of 40 gallons of total drench per acre should be used and exact placement close to the seed is critical to achieve effective control. The 15G formulation is also applied in the furrow at 3.7 ounces/1000 feet of row. There is a 7 day pre-harvest restriction. Chlorpyrifos was applied to approximately 70% of the harvested acres of onions in Wisconsin between 1989-93.

Alternative materials are not generally available at this time. Fonofos (Dyfonate) is an organophosphate soil insecticide that was available as an alternative but has since been withdrawn by the manufacturer.

Diazinon (Diazinon G, EC, WP)
is an alternative organophosphate insecticide registered as a soil insecticide. Diazinon is applied in furrow with a minimum of 40 gallons per acre. Use is restricted to soil with at least 10% organic matter. There is a pre-harvest interval of 14 days. Resistance to diazinon has been shown in several areas however, and this material is ineffective in Wisconsin and was not used in the 1989-93 survey period. Although diazinon is registered for use in Wisconsin, none was applied during the survey years.

A Section 18 registration for cyromazine (Trigard) seed treatment has been in place since 1997 but seed can be treated only in California. Cyromazine is an insect growth regulator which as provided effective onion maggot control but has not been widely used in Wisconsin due to growers' concerns about viability of carryover treated seed and the inability of some growers to use pelleted seed.

Foliar Insecticides for Adult Onion Maggot Control

Several materials are registered for adult onion maggot control but foliar sprays are not generally effective since coverage is difficult to achieve and onion maggot flies migrate in and out of fields.

Synthetic pyrethroids
such as permethrin (Ambush, Pounce), cypermethrin (Ammo, Mustang), and lambda-cyhalothrin (Warrior) are registered for adult onion maggot control but their use should be avoided wherever possible since these materials can select for thrips resistance and reduce the efficacy of thrips control programs in mid-late season. All are restricted-use products.

Diazinon (Diazinon G, EC, WP)
is an organophosphate insecticide registered for adult onion maggot control but is not effective and used in Wisconsin.

Onion Thrips

Onion Thrips can only be controlled with foliar insecticide applications. To achieve effective control, materials should be applied in sufficient water and a spray additive should be used to achieve penetration into the leaf sheaths. Resistance is a primary concern in onion maggot control and although several materials in several chemical classes are registered for thrips control, only the pyrethroids are now effective. To reduce selection pressure, materials should be applied only at threshold levels of 7-10 thrips/plant.

Insecticides Registered for Thrips Control

Organophosphates

- **Azinphos-methyl** (Azinphos-M 50W, WSB, Guthion S, L, WP)
  is a persistent, restricted-use, organophosphate used to control onion thrips. It is applied at a rate of 0.5-0.75 lb a.i./A with a pre-harvest interval of 28 days for dry onions. Azinphos-methyl may be applied to onion foliage either by air or ground. No more than 3 applications may be made per season and at least 7 days between applications on dry bulb onions and 10 days for green onions must be observed. This pesticide was not used on onions grown in Wisconsin during the survey period.

- **Diazinon** (Diazinon EC, WP)
  is an organophosphate insecticide applied at 0.5 lb a.i./A for thrips control. There is a pre-harvest interval of 14 days.

- **Methyl Parathion** (Penncap-M, Methyl Parathion EC)
  is a restricted use, organophosphate insecticide registered for the control of onion thrips. It is applied at a rate of 0.25-0.5 lb a.i./A no less than 15 days before harvest. It should be applied when insects first appear and repeated as needed, but not once onions bloom. Methyl parathion was applied to 75% of the onion acreage in Wisconsin during the survey years of 1989-93.

- **Malathion** (Malathion EC, WP)
  is an organophosphate insecticide registered for the control of onion thrips but it has not provided effective control in recent years.

Carbamates

- **Methomyl** (Lannate L)
  is a restricted-use organophosphate insecticide that has had limited efficacy toward onion thrips. It should be applied at a rate of 1 lb a.i./A when insects first appear and at 5 to 7 day intervals as needed. There is a 7 day preharvest interval.

Synthetic Pyrethroids

- **Cypermethrin** (Ammo, Mustang, Fury)
  is a restricted-use insecticide applied at a rate of 0.375-0.05 lb a.i./A no less than 15 days until harvest.

- **Lambda-cyhalothrin** (Warrior)
  is a restricted-use, synthetic pyrethroid applied to onion foliage as needed at a rate of 0.02 to 0.03 lb a.i./A when thresholds have been exceeded. At this time, it is fairly effective but resistance has been documented in New York state and efficacy has declined somewhat in the Midwest. There is a 14 day preharvest interval. Lambda-cyhalothrin was not applied to onions grown in

Wisconsin during the survey years 1989-93.

- **Permethrin** (Ambush, Pounce)
  is a restricted-use synthetic pyrethroid insecticide. It is applied at a rate of 0.13-0.31 lb a.i./A when thrips first appear and may be repeated as necessary. Permethrin was applied to 62-100% of the onion acreage in Wisconsin during the survey period 1989-93, however it has lost its efficacy due to resistance in recent years.

To maintain thrips efficacy and manage resistance it is important to reduce pyrethroid selection pressure to a minimum. This can be achieved by

- Avoiding pyrethroid application for other onion pests, e.g. onion maggot and aster leafhopper.
- Applying pyrethroids only when thresholds are surpassed.
- Concentrating pyrethroid applications on mid to late season control when populations are most damaging.
- Rotating pyrethroids with other chemistry, particularly in early season, where these are still effective.

Aster Leafhopper

Although aster leafhoppers do not damage onions directly, adult populations often feed on onions in early and mid-season and can transmit aster yellows which reduces yield, quality, and storability significantly.

There are no insecticides registered for control of aster leafhoppers on onions. Pyrethroids (permethrin, cypermethrin, and lambda-cyhalothrin) are effective against aster leafhoppers but are not registered for this pest and they should not be used in early season against registered target insects to preserve late-season target efficacy. Organophosphates (methyl parathion, azinphos-methyl) and the carbamate methomyl (Lannate) are registered on onion and, if used against early and mid-season thrips, would provide leafhopper control without selecting for pyrethroid resistance in thrips.

Diseases

Botrytis Leaf Blight (*Botrytis squamosa)* causes a destructive disease of onion that is commonly found in most onion fields. The disease kills foliage and spreads so rapidly that growers gave it the name "blast". Onion plants are predisposed to blast by other diseases, insect damage, mechanical injury, and air pollution damage. The most effective control for leaf blight is through the use of fungicide sprays. Ozone air pollution aggravates infection by the leaf blight pathogen. Extended periods of leaf wetness

are necessary for infection and the extent of the leaf blight is directly related to the length of time the foliage remains wet.

The fungus survives in the soil and on plant refuse as small black bodies called sclerotia. During cool, moist weather sclerotia give rise to airborne spores. These lodge on wet onion foliage, germinate, and enter the plants through wounds. Symptoms of the disease appear first on the oldest leaves as oval whitish or yellowish spots approximately 1-3 mm long, slightly depressed and bordered with a diffuse silver halo. If the leaf is sliced open, it can be seen that the lesions extend through the thickness of the leaf blade. When conditions favor spread, the disease progresses rapidly and numerous lesions appear on each leaf. Foliage may be severely damaged with substantial reductions in yield. Onions appear to be highly susceptible to leaf blight during the early stages of bulbing. *Botrytis sqamosa* can also proliferate in storage and cause a neck rot.

Botrytis Neck Rot (*Botrytis allii)* is a destructive and widespread storage disease, with the initial infection originating in the field but symptoms generally do not appear until harvest and storage. Infection typically occurs when the weather is cool and moist during harvest and onions do not dry properly. During some seasons growers have lost 50% or more of their crop because of this disease. Growers can decrease their losses by harvesting in dry weather when onions are at full maturity, and storing harvested onions under optimum conditions. The condition of the neck tissue at the time of harvest is important in determining the amount of infection. The more succulent the tissue, the greater the likelihood of infection. If bulbs mature well during dry weather before harvest, the chances of infection are greatly reduced.

The fungus survives in the soil and on crop residues. In moist weather, spores are disseminated by wind and splashing water. Cull piles near onion fields provide a source of inoculum as does infested seed. There is often little or no evidence of Botrytis neck rot up to or at the time of harvest. The disease becomes obvious after onions are topped and have been stored for a few days. Scales begin to soften around the neck progressing toward the base. Infected tissue takes on a brownish, sunken, water-soaked appearance. A definite margin appears between healthy and diseased tissue. Infected tissue may be watery initially, but soon dries out. Under humid conditions, a gray mold often grows between the scales. This mold can often be seen only after removal of one or two outer scales. Small, black fruiting bodies called sclerotia can be seen encrusted on shriveled tissues. Several months often elapse before the entire bulb is destroyed.

Downy Mildew (*Peronospora destructor*) is a potentially serious disease of onions particularly when onions are grown under cool, moist, and humid conditions. The fungus overwinters as mycelium in infected onion bulbs left in field after harvest and cull piles. The fungus may also persist in the soil to infect seedlings planted in the following season. Spores produced during the summer are carried by wind to infect new plants.

Infection occurs on leaves > 10 inches in length. Downy mildew may produce local lesions or it may be

systemic. The older, outer leaves usually become infected first. Local infections appear as pale-green, oval to elongate, slightly sunken lesions on leaves and seed stalks. In moist weather, these areas may be covered with a fuzzy, pale, purplish mold. Later the whole leaf may turn a dull pale green and then yellow. Affected foliage often breaks over and shrivels. Systemically infected plants are stunted and have distorted pale green leaves. Under moist conditions, a fuzzy violet fungal growth develops over the entire leaf surface. Bulbs produced by affected plants are often smaller than normal.

Fusarium Basal Rot (*Fusarium oxysporum f. sp. cepae*) is a widespread disease of onions, but it seldom causes severe losses in most production areas. This disease affects onion plants after midseason and continues after harvest as a storage rot. It is particularly troublesome on soils that are continually planted to onions. Sound cultural practices and proper storage conditions reduce the incidence of this disease. Use of tolerant varieties has also lessened the severity of this disease. Fusarium basal rot is most severe in warm weather with high soil temperatures. The fungus overwinters as thick-walled, resting spores called chlamydospores. Plants are infected primarily through wounds or as a result of infection by other pathogens. Intact tissues may also be invaded. Root maggot injuries are thought to be major entry sites for the fungus. Decay progresses slowly and often doesn't become noticeable until bulbs are in storage.

The leaves of affected plants die back rapidly from the tip as plants approach maturity. Affected roots are dark brown, transparent, and hollow. Most of the roots eventually rot off, and in their place a mass of white moldy growth is produced. The bulbs become soft, and when cut, a semi-watery decay is found advancing from the base of the scales upward. The rot progresses slowly and early infections are often unnoticed at harvest time. Thus, the disease becomes a factor in transit and in storage, where the decay may continue until the bulbs are entirely destroyed. Frequently a secondary wet rot will invade the infected plants.

Onion Smut (*Urocystis cepulae, U. colchici)* is a widespread disease of onions, leeks and shallots. Cold, damp spring weather delays plant emergence and prolongs the period of susceptibility to smut infection. If the weather is warm and dry, the onions germinate rapidly and escape infection.

The smut fungus survives in the soil for many years as multi-celled spores. These spores are highly resistant to environmental change and may remain dormant in the soil for many years. In the presence of a new onion crop the spores germinate. Onions are susceptible to infection by the smut fungus shortly after germination and remain susceptible through the development of one true leaf. The fungus penetrates the cotyledons of developing seedlings. As the disease progresses, pustules, develop which later rupture, releasing spores that re-contaminate the soil. The first symptoms of onion smut appear as brown to black elongated blisters on cotyledons and young leaves. A single lesion may cover an entire leaf causing it to curve downward. The fungus progresses inward from leaf to leaf at the base of the plant. Most infected seedlings die within 3-5 weeks after germination. This is an early and important feature of the smut injury. Plants are usually stunted and may die slowly through a gradual drying out process. If plants survive, the disease becomes systemic. Symptoms of systemic infection are plants which remain vegetative for the entire growing season. If bulbs form, they also become covered with

blackish lesions and are open to attack by secondary organisms. Smut does not cause a rot during storage, but smutted bulbs shrink more rapidly and are more subject to attack by other organisms than healthy ones.

Pink Root *(Pyrenochaeta terrestris* formerly *Phoma terrestris)* is caused by a fungus which is common to many soils and affects the roots of many different plants. The disease is confined to the roots of onion and does not affect bulb, yet it reduces bulb size. Onions can be infected during any stage of growth, yet the disease does not appear nearly so often in seedlings as in the mature crop. Pink root generally attacks weakened roots of mature plants. However, seedlings can also be infected. The fungus can survive in the soil for several years in the absence of host plants.

The fungus that causes pink root overwinters in the soil. Symptoms first appear 7-21 days after infection. As the fungus grows within the plant, it moves through the cortex of the roots. Fruiting bodies called pycnidia are produced in dead tissue. Conidia produced in pycnidia can lead to further infection of other plants. Diseased plants can easily be pulled out of the soil, revealing a substantially reduced root system. Affected roots turn pink, shrivel and die. Eventually new roots become diseased and suffer loss of function. The disease continues throughout the growing season, rarely killing the infected plants, however bulb size is reduced. During severe infections, onion tops turn white, yellow or brown and finally die. Plants infected early in the season do not bulb properly, while the later infected plants have stunted or softened bulbs. The disease becomes more apparent at harvest time when the size of the bulb is often inversely proportional to the severity of the attack.

Purple Blotch *(Alternaria porri)* may cause onion leaves to become blighted and die prematurely. The result is undersized and immature bulbs, thereby reducing yields. The destructiveness of the disease varies widely with locality and season, and depends upon how often , and how long onion foliage is wetted by dew, fog, or showers. Yield increases of 20-35% or more have been recorded in fields sprayed with fungicides used to control purple blotch.

The fungus overwinters as mycelium in diseased plant debris and produces spores under favorable conditions in the spring. Initial symptoms appear as small, water-soaked, brownish areas on leaves, flower stalks, and floral parts of onions 1-4 days after infection occurs. As the spots enlarge, they assume a zonate appearance and become somewhat sunken and purplish in color. The lesion border is reddish or purple with a yellow halo that extends for some distance above and below the center of the lesion. Lesions may girdle the entire leaf. Onion bulbs may be infected at harvest or later, in storage through the neck or through wounds in the bulb scales. The rot is semi-watery and yellow at first. The color gradually turns wine-red and finally dark brown or black. Diseased bulb tissue gradually dries out and becomes papery.

Chemical Controls for Diseases in IPM & Resistance Management Programs

Wisconsin onion growers use an onion disease prediction program to determine when protectant fungicide applications are necessary. Through disease and weather monitoring, growers have been able to delay protectant sprays thereby reducing the amount of pesticide residue. Currently a combination of mancozeb and chlorothalonil are used to manage onion disease. A loss of mancozeb would force growers to rely solely on chlorothalonil for control. Although chlorothalonil provides good control, an undesirable side effect is a delay in the natural senescence of the crop. By not allowing the foliage to dry down properly and seal the neck, the crop is made more susceptible to many post-harvest storage diseases. The crop requires disease protection up until harvest and this is when growers are more likely to use mancozeb which doesn't have the same untoward effect of senescence delay that chlorothalonil has.

- **Chlorothalonil** (Bravo, Terranil - several formulations)
  is a broad-spectrum, protectant fungicide registered for the control of *Botrytis* leaf and neck blights and *Alternaria* purple blotch. It is applied every 7-10 days at a rate of 1.0-2.0 pints/A of commercial product. Chlorothalonil is often alternated with maneb, mancozeb, and iprodione and should not be applied within 7 days of harvest. One hundred percent of the onion acreage grown in Wisconsin during the survey years 1989-93 were treated with chlorothalonil 2-7 times per season.

  If the chlorothalonil label was lost, mancozeb and iprodione would replace it.

- **Copper hydroxide** (Champ, Kocide)
  is registered for the control of purple blotch and downy mildew. It is applied at a rate of 1.3 pt/A of Champ or 2.0 lb/A of Kocide. It may be useful in reducing losses to bacterial infections as well during periods of wet weather. Copper hydroxide was not used on onions grown in Wisconsin during the survey years.

- **Iprodione** (Rovral)
  is a protectant fungicide registered for the control of *Botrytis* leaf and neck blight and purple blotch. It is applied at a rate of 1.5 lb/A of commercial product every 7 days as needed during periods when conditions favor the disease. No more than five applications may be made per season and there is a 7 day pre-harvest interval. Iprodione was applied to 100% of the onion acreage in Wisconsin during the survey years.

- **Maneb** (Maneb)
  is a broad-spectrum, protectant fungicide registered to control *Botrytis* leaf blight and neck rot, *Alternaria* purple blotch and downy mildew at a rate of 2.0-3.0 lb/A when symptoms are first observed. It may be repeated at 7 day intervals throughout the season as long as no more than 24 lbs. active ingredient (30 lbs. product) are applied per acre per season. There is a 7 day pre-harvest interval.

- **Mancozeb** (Dithane, Manzate, Penncozeb)
  is a broad-spectrum, protectant fungicide registered to control *Botrytis* leaf blight and neck rot, *Alternaria* purple blotch and downy mildew at a rate of 1.6-2.4 qt./A Dithane or 2-3 lbs/A of Manzate or Penncozeb. It can be sprayed every 7-10 days, as needed, depending on weather conditions. It should not be applied to exposed bulbs or within 7 days of harvest. To treat smut, Dithane and Penncozeb is applied at a rate of 3 lb/A as a furrow drench when planting seeds. It should be in 75-125 gal/A of water. Mancozeb was applied 5-8 times to 100% of the planted acreage in Wisconsin between 1989-93.

- **Mefenoxam** (Ridomil Gold MZ, Ridomil Gold Bravo)
  is registered for control of downy mildew. Ridomil is applied at a rate of 2.0-2.5 lb/A in sufficient water to get complete foliar coverage. It should be applied when conditions are favorable for the disease, but before infection occurs, and continued at 14-day intervals until the threat of disease is over. It is best to alternate with other protective fungicides. No more than 4 applications per season should be used and not applied within 7 days to harvest.

Critical Pest Control Issues

In recent years, Wisconsin growers have observed an increase in the amount of smut on onions. This soil-borne problem is currently being treated with in-furrow applications of mancozeb. A loss of this product would cause significant economic loss if the prevalence of onion smut continues to increase.

Insecticide resistance management is critical for the continued control of the key onion pests. Without alternative chemistries, insecticide resistance pressure will become more problematic.

Weeds

Onions are very sensitive to competition from weeds for many reasons and hence, weed control is crucial in onion production. Because of their slow growth, small stature, shallow roots, and thin canopy, onion seedlings are poor competitors with weeds. When grown from seed, onions are very slow to emerge, which gives weed seedlings a chance to become established before the crop emerges. The presence of weeds during crop establishment can greatly reduce yields because the onion is a very shallow-rooted crop and cannot compete very well for water and nutrients. Weeds can also cause a problem in established onion fields because onion plants have a relatively short stature and an upright leaf habit that doesn't effectively shade out competing weeds. Weed pressure before bulb formation significantly reduce yields. Later in the season, weeds may shade the bulbs and keep onions from drying quickly. Weeds that germinate later in the season have less impact on yield but they can interfere with

mechanical harvesting equipment. As a result, chemical weed control is used extensively in commercial onion production.

With the development of bedding systems for onions, cultivation may be a practical method of weed control--rolling cultivators that are guided by the bed allow accurate and relatively fast cultivation. However, while a cultivator will control some of the herbicide-resistant weeds, it will not replace chemical control. Chemical weed control is the primary weed management option in Wisconsin onion production. Several herbicides are used for weed control in onions since no single herbicide is effective for all situations and continued reliance upon a single herbicide class will lead to the evolution of resistant weeds. In addition, the successful control of the key weed species today will eventually lead to outbreaks of secondary weed pests.

Annual broadleaf weeds are a major problem in onion fields in Wisconsin. Seeds can germinate throughout the summer if adequate moisture is present. In the absence of regular moisture, flushes of seed germination often coincide with rainfall events or irrigation. Pigweed (*Amaranthus spp*.) is a vigorous annual that produces a very large number of seeds that can survive in the soil for up to 40 years. Within the pigweed group, the most serious species is redroot pigweed (*Amaranthus retroflexux*). Fields with a history of redroot pigweed must have pre-emergence or early post-emergence herbicides to prevent outbreaks in the current season.

Another important annual broadleaf weed is common lambsquarters (*Chenopodium album*). Common lambsquarters is a very adaptable weed that sets thousands of seeds and, like pigweed, can remain in the soil for many years. Most seeds germinate early in the growing season and control should be targeted for this time. Lambsquarters are vigorous competitors of nutrients. Dense stands can smother onion seedlings.

Prostrate spurge (*Euphorbia humistrata/maculata*) is another annual broadleaf that presents a large problem in onion fields. It has a low growth habit and can go unnoticed until seed set has occurred. Mature plants may smother onion plants and pose a harvest problem.

Other annuals that are a problem in Wisconsin onion fields are common purslane (*Portulaca oleracea*), shepherd's purse (*Capsella bursa-pastoris*) and common ragweed (*Ambrosia artemisifolia*).

Annual grasses (Gramineae family) are also serious pests in onion fields because of their vigorous growth and ability to produce copious amounts of seed. This group of weeds pose the greatest competition to onions. They are also very tolerant to moisture and temperature extremes once they are established. If uncontrolled, grass weeds can root and branch from the lower joints and stems. All annual grasses should be controlled before they set seed. Presently, good grass herbicides that are available prevent competition problems but the loss of fluazifop-P-butyl and sethoxydim would allow annual grass weeds to present a serious problem in onion culture.

Sedges are another key weed in onion production. Yellow nutsedge (*Cyperus esculentus*) is a perennial

monocot with grass-like foliage. It is one of the most serious onion weed pests on both muck and mineral soils. Even light infestations can reduce onion growth and bulb size. The plant reproduces by seed and underground tubers called nutlets. The underground tubers can overwinter and survive soil temperatures of -20F. The tubers sprout from May to late July and each sprouting tuber is capable of producing numerous plants.

Chemical Controls for Weeds in IPM & Resistance Management Programs

At the present time, the weed management tools for onions are pretty effective and can be used in rotation to control escaped weeds and in conjunction with IPM scouting programs. Oxyfluorfen, bromoxynil, metolachlor, and pendimethalin can be used as either a pre-emergent treatment or as a post-emergent treatment for weeds that escape early season control. Both metolachlor and pendimethalin are necessary despite the overlap in weed species controlled. Both have a somewhat different spectrum of control. In addition, pendimethalin provides good control of spurge while metolachlor is somewhat effective on nutsedge but at the present time, it's the only herbicide labeled for nutsedge in Wisconsin. In these situations, the two products are not interchangeable.

Broadleaf Herbicides

- **Bromoxynil** (Buctril)
  is a selective, post-emergent, contact herbicide that is registered for the control of annual broadleaf weeds. It is labeled at a rate of 0.25-0.375 lb a.i./A in 50-75 gallons per acre water but is actually applied at a rate of 0.08-0.125 lb a.i./A when onions are in the two to five true leaf stage. If it is applied to younger or older onions it may cause crop injury. It must be applied to weeds when they are less than 2 inches tall. It is applied when soil and onion leaves are dry, and when the temperature is 70-85F. Buctril should not be applied to onions that are damaged by insects or blowing sand. At least 75% of the Wisconsin onion acres grown between 1989 and 1993 were treated with bromoxynil each year.

Grass Herbicides

- **Clethodim** (Select, Prism)
  is a selective, post-emergence herbicide registered for the control of annual and perennial grasses in onion fields. Applications should be made when actively growing grasses are in the size ranges specified on the product label. It is applied at a rate of 0.10-0.125 lb a.i./A no less than 45 days until harvest. A crop oil concentrate containing at least 15% emulsifier at 1% v/v should be used in finished spray volume. No more than 0.5 lb a.i./A or 0.125 lb clethodim should be applied in one crop season. This herbicide was not used in Wisconsin during the survey years.

- **Fluazifop-P-butyl** (Fusilade DX)
  is a selective, post-emergence herbicide registered for the control of annual and perennial grass weeds. It is applied at a rate of 0.13-0.19 lb a.i./A no less than 45 days to harvest. Post-emergent applications should be made when actively growing grasses are in the sizes specified on the label. Multiple applications can be made to control late germinating grasses, but should not exceed 3 pt Fusilade DX per acre in one crop season. Fluazifop-P-butyl was applied to at least 75% of the onion acreage in Wisconsin during each of the survey years.

  If fluazifop-P-butyl were unavailable, sethoxydim could be substituted and onion yield and quality would be the same. Controlling weeds with fluazifop-P-butyl is more costly than sethoxydim and onion growers would realize a national savings of $3.6 million by switching from fluazifop-P-butyl to sethoxydim.

- **Sethoxydim** (Poast)
  is a broad-spectrum, post-emergent herbicide that is registered for the control of annual and perennial grass weeds. It is applied at a rate of 0.19-0.28 lb a.i./A. to actively growing grasses within the size ranges specified on the label. No more than 4.5 pt Poast per acre should be applied in one crop season. 2 pt of oil concentrate per acre should always be added. There is a 14 day pre-harvest interval. At least 75% of the onion acreage grown in Wisconsin from 1989-1993 were treated with sethoxydim on an average of 0.75-1.5 times per season to control mainly barnyardgrass, crabgrass, and witchgrass.

  If sethoxydim were unavailable, fluazifop-P-butyl would be used, and onion yield and quality would be the same. Controlling weeds with sethoxydim is less costly than fluazifop-P-butyl and in the northeast region alone, costs would increase $28,000 if growers switched from sethoxydim to fluazifop-P-butyl. Although it may appear that fluazifop-P-butyl and sethoxydim are interchangeable, there is actually a difference in the spectrum of weeds controlled by each product.

Broadleaf and Grass Herbicides

- **Glyphosate** (Roundup Ultra)
  is a non-selective, post-emergent herbicide that controls all broadleaf and grass weeds. It is applied at a rate of 0.28-1.12 lb a.i./A to actively growing weeds before crop emergence in direct seeded fields or before transplanting seedlings or sets. Only 5% of the onion acreage grown in Wisconsin from 1989-1993 was treated with glysophate.

- **Metolachlor** (Dual 8E)
  has a 24c (Special Local Needs) label for the control of annual broadleaves and grasses and yellow nutsedge. It is applied at a rate of 1.0-2.0 lb a.i./A no less than 60 days until harvest. Dual 8E will not control emerged weeds, and should be applied at the two true leaf stage of onion

development to clean-tilled soil. A lower rate should be used on light, sandy soils. An additional treatment can be made 3-4 weeks after the first application on muck soils (organic matter greater than 5%). Before using Dual 8E, growers must obtain a copy of the label and sign a waiver of liability and indemnification certificate each season. Metolachlor is applied to 1500 acres in Wisconsin

- **Oxyfluorfen** (Goal)
  is a post-emergenct, selective herbicide registered for the control of emerged annual broadleaf and grass weeds. It is applied at a rate of 0.12 lb a.i./A in seeded onions when onions have at least two true leaves and weeds are in the two- to four-leaf stage. It can cause injury on young or "soft" crops or crops that are under stress and should not be applied during extended periods of cloudy, humid weather when soil moisture is plentiful. Multiple treatments can be made, but shouldn't exceed 2.5 pt. Goal 1.6E per acre or 2.0 pt. Goal 2XL per acre in one season. One hundred percent of onion acreage in Wisconsin from 1989-1993 was treated with oxyfluorfen an average of 4-8 times per season. The principal target weeds were redroot pigweed, prostrate purslane, and prostrate pigweed.

  If oxyfluorfen were not available, bromoxynil would be applied. A average national yield loss of 5-20% on the acres that were treated with oxyfluorfen would result from replacing oxyfluorfen with bromoxynil. The overall cost (cost of replacement chemicals plus yield loss) of replacement would be $40 million nationally.

- **Pendimethalin** (Prowl 3.3)
  is a pre-emergent herbicide registered for the control of annual grasses and selected annual broadleaves. It is applied at a rate of 0.5-1.5 lb a.i./A when onions are in the 2-9 true leaf stage with a 45 day pre-harvest interval. The principal target weeds were controlled with pendimethalin include prostrate pigweed, redroot pigweed, common lambsquarters, knotweed, smartweed, and common purslane. One hundred percent of the onion acreage grown in Wisconsin between 1989-93 was treated 1-3 times with pendimethalin.

  If pendimethalin were not available, oxyfluorfen would be substituted. Yield loss data is not available for Wisconsin but a 20% yield loss would result in the northeastern growing region if pendimethalin was replaced with oxyfluorfen. The overall cost (cost of replacement chemicals plus yield loss) of replacing pendimethalin with oxyfluorfen would be $55 million nationally.

Outlook for New Registrations

- In the herbicide arena, new, more active products that require the use of less active ingredient to achieve effective control are desired.

- Currently there are a limited number of new fungicides on the horizon, including Quadris and

Switch. If mancozeb were to lose its label, an effective replacement must be found if economical onion production is to continue in Wisconsin.

- Fipronil (Regent) is an experimental insecticide which has demonstrated efficacy on onion maggots and could have potential as an alternative control.

- Future potential alternatives for onion thrips control include chlorfenapyr (Alert) and fipronil (Regent) which are experimental at this time.

Contacts

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