Crop Profile for Soybean in Minnesota

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General Production Information

Overview

Insects and mites rarely threaten soybean production in Minnesota. This is the result of the introduction of clean soybeans from Korea and China without insect pests. Most insect pests of soybean have adapted to the crop from other native plants. As a result, most insect problems are infrequent and localized; examples of infestations occurring over the past 15 years in Minnesota have included two-spotted spider mite (1988), grasshopper (1989-90), thistle caterpillar (1992), and white grub (1998-2000). A pest of significant concern is the soybean aphid. Native to Asia, the soybean aphid has spread across North America over the past 4-5 years. No soybean production area is immune to insect outbreaks and as acreage expands into northern Minnesota, additional insect problems could develop.

Diseases among Minnesota soybeans and underestimation of disease-incurred yield reduction are significant among the crop. Diseases are second to weeds as the most common yield-limiting or yield-reducing pest in soybean. They are characterized as seedling damping off/root rots, stem diseases, foliar diseases, virus diseases, and nematodes. Fungicides are most commonly used as seed treatments for seed-borne diseases and damping-off fungi; although foliar fungicides are labeled for several foliar soybean diseases, they are cost-prohibitive in many situations. Large numbers of nematodes exist in all soil types, but relatively few are economically important on soybeans. Nematode damage can be both direct and indirect in soybeans. Nematode damage can be significant and difficult to accurately diagnosis without proper sample collection and identification, including both soil and root samples.

Weeds compete with the soybeans for light, moisture, and nutrients. Uncontrolled, weeds reduce soybean yields and interfere with harvest. A 1992 report of the Weed Science Society of America estimated that weeds are responsible for greater than a $52 million loss among Minnesota soybeans annually. Effective weed management program requires understanding potential weed problems and planning to control weeds in a timely manner. Soybeans are very competitive with weeds once they develop a canopy, but if early emerging weeds left uncontrolled can significantly affect yield. Early season weed control is the key to providing soybeans with a competitive advantage. Most effective weed management programs include a variety of control practices in an integrated approach.

Worker In-Field Activities

Planting typically begins after corn has been planted, typically early May through late June. Herbicides are available for early preplant, preplant incorporated, pre-emergence, or postemergence application on

soybeans. In spite of the prevalence of soybean diseases, fungicides including seed treatments are not widely used in Minnesota. Insect pest problems are infrequent and sporadic; as a result, most fields are not treated with insecticides. Mechanical harvesting takes place in the fall when soybeans are combined in the field. There is very little in-field time logged by producers of soybeans, however, the recent explosion of soybean aphid is prompting some growers to scout fields or pay for this service.

Minnesota ranks third, nationally, in soybean production with approximately 309 million bushels, 11% of total US production. Soybeans are grown for oil, meal processing, animal feed, and food in Minnesota.

Table 1. Top 10 soybean producing states in the US, 2002.

Rank	State	Planted Acres (million)	Harvested Acres (million)	Average Yield (bu/ Ac)	Production (million bu)	Value (billion $)
1	IA	10.5	10.4	48.0	499.2	2.67
2	IL	10.6	10.6	43.0	453.7	2.47
3	MN	7.2	7.1	43.5	308.9	1.62
4	IN	5.8	5.8	41.5	239.4	1.27
5	NE	4.7	4.6	38.5	176.3	0.94
6	MO	5.1	5.0	34.0	170.0	0.92
7	OH	4.8	4.7	31.0	146.3	0.77
8	SD	4.3	4.1	31.0	126.8	0.65
9	AR	3.0	2.9	33.5	96.4	0.55
10	ND	2.7	2.6	33.0	86.8	0.45
Total	**US**	**73.9**	**72.4**	**38.0**	**2,749.3**	**14.76**

Table 2. Minnesota soybean production areas.

Production Region	Soil Types	Crop Maturity	Major Crops	Livestock Production
SE	Loess	Late I-Early II	Corn, alfalfa, processing crops	Dairy, Beef cattle
SW, W. Central, Central	Glacial till, Loess	Early I-Early II	Corn, sugarbeet	Confinement Hogs, Beef cattle

S. Central, Central, W. Central	Glacial till	Early I (N) Mid I-Early II (S)	Corn, processing crops, sugarbeet	Confinement Hogs, poultry
NW	Lacustrian	Early 0-Early I	Corn, small grains, sugarbeet	--

Table 2 classifies Minnesota soybean production by climate, soil and geographic area. Most of Minnesota's soybean production is located in the southern and western part of the state where soybean production is located on gently rolling glacial till soils. Minnesota soybeans are also grown on Loess soils in southeast and extreme southwest Minnesota. South central, central and southwest Minnesota soybeans are primarily rotated with corn and are grown in association with confinement hog production and poultry production. Southeast Minnesota topography is characterized by greater relief and has a greater portion of acres in continuous corn, corn/alfalfa rotations or dairy production.

Soybean acreage is increasing in northwest Minnesota, predominantly the Red River valley, as soybeans replace small grain production. Polk County ranked the top ten for Minnesota soybean production in the 2000-growing season. This area is dominated by nearly level lacustrian soils with little livestock production. Northwestern Minnesota soybeans are rotated with sugarbeet, small grains and dry edible beans in addition to corn. Shorter growing seasons in this part of the state necessitate extremely short season varieties.

Climatic conditions vary widely for Minnesota soybean production. Average annual precipitation varies from 20 inches in the northwest to 31 inches in the southeast. The average frost-free dates (32 degrees F) vary by more than 35 days through the portions of Minnesota where soybeans are grown. Soybean maturities range from early Group II in the south to Group 0 in the northwest. Some calcareous soils in the south-central and especially in the west-central and northwest parts of the state are poorly drained. Alkaline soils contribute to iron deficiency symptoms on susceptible varieties.

Cultural Practices

Corn planting in southern Minnesota begins April 15 or as soon thereafter as field conditions allow. Soybean planting typically follows corn with some growers delaying planting until after May 1 to avoid frost. Planting usually begins in southwest Minnesota due to warmer temperatures and lower soil moisture in spring. Most Minnesota soybeans are grown under conventional or reduced tillage systems but poorly drained soils and a short growing season limit the number of acres of no-till soybeans in the state. Additional acres are planted under ridge and strip till systems but erosion concerns limit fall tillage of soybean stubble in many areas of the state. In addition, most soybean fields receive herbicide treatments. In spite of the prevalence of soybean diseases, fungicides including seed treatments are not widely used in Minnesota. Insect pest problems are infrequent and sporadic and most fields are not

treated with insecticides.

Insect Pests

Overview

Insects and mites rarely threaten soybean production in Minnesota. This situation has resulted from the introduction of clean soybeans from Korea and China without the importation insect pests. The pests highlighted in this section have adapted to soybeans from other native plants. Consequently, insect problems are infrequent and localized. For example, infestations over the last 15 years have included two-spotted spider mite in 1988, grasshopper in 1989-90 and 1997-98, green cloverworm in 1991, thistle caterpillar in 1992, seed corn maggot in 1993 and 1999 - 2000 and white grub from 1998-2000. Infrequent infestations pose three problems:

- Soybeans are infrequently scouted and infestations may not be detected promptly
- When/if infestations are noticed, growers and crop advisors may have difficulty diagnosing problem insects and mites
- Sporadic problems mean most growers or crop advisors lack management expertise, especially for spotty problems that may occur once every 10-20 years

A new pest of significant concern is the soybean aphid. Native to Asia, the insect has likely been dispersing in North America for 4-5 years. Geographical variation is typical with migratory insect problems, such as green cloverworm and potato leafhopper, both of which are more common in southern Minnesota. There can also be drought-related insect problems such as grasshoppers and two-spotted spider mites, which are more common in western Minnesota. No area is immune to insect outbreaks and as soybean acreage expands in northern Minnesota, more insect problems could develop.

Types of Damage

Insects and mites attacking soybeans can be grouped by the type of damage they cause, and can be categorized as **stand-reducing, leaf-feeding, and pod-feeding**.

Stand Reducers

Stand reducing insects attack germinating seeds, roots or underground stems of young plants. Examples include seedcorn maggot, wireworm, white grub and cutworm spp. Three factors influence stand reduction and management decisions. First, because the seed rises out of the ground during emergence, its exposure to seed-feeding insects is greatly reduced. Second, because the growing point rapidly moves

above ground, the risk of stand loss from cutworms is increased. Third, soybeans compensate quite well for stand loss; stand reductions from 160K to 105K may not cause detectable yield loss. Rescue insecticide treatments are not available for most stand-reducing insects; however, cutworm infestations can be controlled with insecticides if the insects are detected when the crop is in an early stage of development.

Seedcorn Maggot: larva of a small fly resembling a housefly. The flies are attracted to fields where decaying organic material is present and are most often a problem where large amounts of solid manure or weeds/cover crops are incorporated shortly before planting. Larvae prefer to feed on seed that has imbibed water and softened or germinated and cause damage to the plant which includes feeding on the cotyledons and growing point while still below ground. Feeding damage can open avenues for pathogens. Additionally, damaged growing points can lead to the development of basally branched plants which are slightly delayed developmentally and prone to breakage during pod fill. Damage is increased when cool soil conditions delay soybean emergence or in wet soils which favor disease development. There are no rescue treatments available for control of seedcorn maggot, insecticidal seed treatments are recommended when planting into high-risk situations or replanting after stand loss has occurred.

Wireworms: larvae of click beetles. Wireworms are rarely a problem in soybean but they can attack germinating seeds and the soft, underground portions of stems. Damage has been reported when soybeans follow sod, such as pasture or Conservation Reserve Program (CRP) land that was reclaimed for crop production. Low-lying areas of fields already in production can also experience problems, particularly if weather following planting is cool and wet enough to delay germination. Seed treatments are typically recommended for these higher-risk situations.

Cutworms: larvae of Noctuid moths. They have visible prolegs and a hardened prothoracic shield behind the head. Cutworms will curl into a ball if disturbed (not to be confused with white grubs, or Japanese beetle grubs, which are C-shaped). Cutworms can attack seedling plants by girdling or cutting through young stems. Several species, including sandhill, glassy, dark-sided, red-backed, and dingy cutworms overwinter as eggs or larvae. Black cutworm, a migratory species most commonly associated with corn damage, also occasionally attacks soybeans. Rescue insecticide treatments when combined with scouting and stand loss thresholds are the most cost effective control tactic for cutworms.

White Grubs: larvae of June beetles. White grubs are white to cream-colored C-shaped larvae, 1/4-1 1/4 inches long, which can feed on soybean roots. Symptoms of feeding include wilting and stand loss and are often associated with root rot fungi. No rescue treatments are available and soil insecticides are not labeled for white grubs in soybean. If a problem is anticipated, or if abundant grubs are detected at tillage, consider planting corn with a soil insecticide.

Leaf Feeding Insects

These insects remove or damage leaves, which may affect future growth, pod-set, or pod-fill. Examples of defoliating insects include grasshoppers, bean leaf beetles, and several caterpillars (green cloverworms, yellow woollybears, thistle caterpillars or webworms). Each defoliating insect produces a unique type of feeding damage. In contrast, the potato leafhopper uses its piercing/sucking mouthparts to damage leaf phloem. Two-spotted spider mites suck out leaf cells.

Leaf feeding is initially obscure but may rapidly escalate. Defoliation always appears worse than the resulting yield loss, because soybean canopies have more leaf area than they need to produce a good bean crop. The impact of insect defoliation on yield can be estimated from hail loss tables, however, hail is a one-time event, whereas ongoing insect defoliation or mite injury at the same level causes greater yield loss. Factors affecting good canopy formation, such as drought, disease, or stand loss will accentuate defoliation impacts on yield. Soybean susceptibility to defoliation also varies with growth stage. The greatest susceptibility occurs during pod-fill.

Bean Leaf Beetle: see "Pod Feeding Insects"

Grasshoppers: differential, two-striped and red-legged grasshoppers are the most common Minnesota species defoliating seedling through maturing soybean. Damaging grasshopper populations develop during several years of dry springs following long, warm autumns. Under moderate or high moisture, fungal diseases will keep grasshopper populations in check. Grasshoppers prefer to lay eggs in undisturbed areas including roadsides and ditches. Damage, therefore, will likely first occur at the margin of fields. An exception is soybean planted into the previous years' soybean or alfalfa fields; differential and red-legged grasshopper will lay eggs in these crops, respectively. Grasshopper nymphs look much like adults, but lack fully developed wings. Grasshoppers will feed on leaves and developing pods.

Scouting for grasshoppers should start early in the growing season (late April-early May) because early detection is instrumental in their control. Scouting should start at field edges, fence rows, dirt roads, and ditches. Consider field-edge applications unless grasshoppers occur throughout the field. Thresholds can be based on either grasshopper numbers or soybean defoliation. Thresholds based on grasshopper populations can be estimated by scouting. Thresholds based on defoliation include treating when defoliation inside the field exceeds 30% pre-bloom, or 20% blooming-to-pod-fill.

Green Cloverworm: migratory moth is common throughout the soybean-growing areas of the eastern United States and the Great Plains, but seldom reaches pest status. The caterpillar is green with white lines and typically has two generations per year. This insect is present early in the season; therefore plants usually compensate for foliage loss prior to pod set. Many entomologists consider the green cloverworm a valuable food source for beneficial insects and diseases and this reservoir of beneficials will controls pests of greater economic importance later in the season. Treat only when defoliation reaches 40% in pre-bloom, 20% during bloom and pod-fill, and 35% from pod-fill to harvest.

Potato Leafhopper: small (1/8 inch), wedge-shaped insects. They are bright green, quick moving, and

have piercing/sucking mouthparts. When feeding, they inject toxic saliva which causes localized stippling, yellowish to reddish-yellow discoloration of leaves (especially at the tips), leaf crinkling and cupping, injuries which appear to be consistent with herbicide damage. Extensive feeding damage can result in plants appearing stunted. The thick pubescence on soybean leaves tends to prevent this small insect from getting close enough to implant its mouthparts, however, young plants without heavy pubescence are vulnerable to leafhopper attack. Stressed plants are also more vulnerable to injury from potato leafhopper than are healthy plants. In addition, due to this insect's host preference, soybean fields adjacent to alfalfa fields should be considered at a greater risk from potato leafhopper infestation due to insect movement when alfalfa is cut. Scout for potato leafhopper by examining fields with two trifoliolates or less, and treat if populations exceed l PLH/plant at V2, or if seedling plants with dying leaves are present.

Saltmarsh and Woolybear Caterpillars: larvae of several species of tiger moth. These hairy, robust caterpillars may be white or multicolored, solid, or banded. They often feed in the upper canopy where they are noticeable, so populations are frequently overestimated. Smaller larvae tend to feed in the lower canopy or on the underside of leaves, so early infestations can go unnoticed. These insects are an occasional problem in Minnesota, damaging soybean primarily during drought years.

Two-Spotted Spider Mites: in most years, spider mite populations are kept in check by fungal diseases and predators. In very warm, dry years spider mite populations can rapidly increase and cause widespread damage through soybean fields. Early infestations will kill soybeans, while later infestations cause premature senescence and reductions in yields up to 40%-50%. Soybeans planted next to alfalfa are at high risk during favor-able mite conditions, and should be scouted first. Look for stippling and bronzing of soybean leaves. Fully grown adult mites will be barely visible to the naked eye on the underside of leaves, while younger stages will have to be observed with a hand lens. Treat only in outbreak conditions when mites are present throughout the field, and stippling is present on leaves. Re-infestation may occur because some of the insecticides used may not be effective against eggs. The eggs will hatch in several days, and the infestation may begin again, so continued scouting is recommended. Border-treating fields may be effective if the problem is caught early.

Thistle Caterpillars: larvae of the painted lady butterfly rarely cause problems in soybeans unless an unusually large spring migration occurs from the Southwest U.S. or Mexico. The caterpillars are commonly found on thistle, but will also attack early vegetative soybeans. Larvae (up to 1.5 inches long) feed on the top leaves and web them together with silk. Their appearance is quite distinctive: their bodies are black with yellow spots and they have numerous multi-pronged spines. The treatment threshold for thistle caterpillar is 50% defoliation.

Webworms: green caterpillars with 3 dark spots arranged in a triangle on the side of each body segment. At least one hair originates from each spot. These are rarely a problem in Minnesota, and have never reached economic threshold.

Soybean Aphid: first identified in Minnesota in 2000 and during 2001 spread rapidly across the state.

Soybean aphid is native to China where it has been shown to cause significant yield losses (up to 58%). Aphids colonize soybean relatively early (V1-V2) near overwintering areas (Buckthorn) and subsequent population buildup can be dramatic with aphid densities exceeding 8,000/plant in severely infested fields. Soybean aphid damages plants by feeding on phloem with symptoms including plant stunting, malformation of leaves, and reduced numbers of pods. In addition to direct damage caused by aphid feeding, soybean aphid has been demonstrated to transmit soybean mosaic virus. Scouting methods and treatment thresholds are still in development. A field trial which compared insecticide-treated and untreated strips reached 32 bu/acre with the typical response >9 bu/acre. Pod set is the yield component hit hardest, indicating fields should be scouted in early July, and if densities warrant, fields should be treated during the third week of July. Long- term status of the aphid is unknown as natural enemies adjust to its presence and the aphid continues to colonize the state.

Pod-Feeding Insects

Pod-feeding insects attack developing pods, or even cut pods off the plant. Examples include grasshoppers and bean leaf beetles. Because the soybean's investment in yield is nearly completed, this type of attack is the most destructive. Pod-feeding is difficult to anticipate. Equivalent infestation levels may or may not produce economic loss. Assessment of seed damage or pod loss can indicate when to treat an infestation. However, this approach can only prevent further losses from that point on. Pod feeding insects, in addition to obvious quality losses caused by feeding on seed, can open a pathway for fungal and viral disease.

Bean Leaf Beetle: small (1/4 inch) yellowish-buff to reddish beetles usually sport four distinct black spots on their back. A small proportion of the beetles lack spots, but all color forms have a black triangle at the base of the wing covers. The bean leaf beetle attacks soybeans throughout the growing season. Overwintering adults colonize early-emerging soybean fields, but beetle feeding on cotyledons and unifoliolate leaves does not reach economic threshold. There is one generation in the north and up to two in the south of Minnesota per year. Larvae feed underground on soybean roots and nodules, but this feeding does not appear to affect yield. Emerging adults from the first generation feed on soybean leaves in July and should be treated if defoliation exceeds 35% and beetles are still feeding. Adults from the second generation should be treated in late August if defoliation exceeds 25% during pod-set and pod-fill. These adults also feed on pods, which affects seed development and allows disease entry. Bean leaf beetle feeding is known to transmit or encourage bean pod mottle virus and *Phomopsis.* Consequently, these beetles should be treated if damaged pods exceed 10%, or if adults exceed 0.5 per plant, during pod-fill. Heavy populations should be watched closely and treated aggressively if pod clipping is noted.

Grasshopper: see Leaf-Feeding Insects

Insect Interactions of Soybeans with Other Crops

Cutworms: Dingy cutworm and black cutworm problems in corn are more severe following soy- beans.

Dingy cutworms prefer laying eggs in soybeans and alfalfa when adults are active in August and September. Consequently, crops following soybeans have a higher risk of attack from this cut- worm. The black cutworm migrates north each spring. Arriving moths lay eggs in crop and weed residue, and soybean residue is a preferred egg-laying site. The timing and extent of tillage have important implications for risk of cutworm attack. Ridge-till and no-till corn after soybean often have the most severe infestations.

Stalk Borer and Giant Ragweed: Giant ragweed has emerged as a weed control problem in some soybean herbicide programs. This weed is a preferred egg-laying site for stalk borers. Corn planted the next year may suffer severe infestations, particularly if the weed control program in corn forces any stalk borers in giant ragweed into corn. While stalk borers are more commonly recognized as an insect problem in corn, they may also attack soy- beans.

Crop Rotation and Corn Rootworm: Rotation to a non-com crop, such as soybeans, is a highly-preferred and effective way to avoid corn rootworm problems. Recently, corn rootworms have demonstrated their capability to survive crop rotation. The northern corn rootworm retains its egg laying preference for corn, but a larger proportion of eggs overwinter two or more years. The western corn rootworm has shifted its egg laying to soybeans in the eastern portion of the corn belt (Illinois, Indiana, Ohio, Michigan). These problems could affect crop rotations throughout the corn belt, including Minnesota.

Insecticides:

- **Organochlorines**
    - Lindane
        - Trade name and formulation: various
        - Use rates: see individual label
        - Application: seed treatment
        - Pre-harvest interval: NA
        - Grazing Feeding interval: REI: NA
        - Restricted use: No
        - Primary use: seed corn maggot, wireworm
- **Carbamates**
    - Carbaryl
        - Trade name and formulation: Sevin XLR Plus, others
        - Use rates: 0.5-2.0 qts/Ac
        - Application: post emerge rescue

        - Pre-harvest interval: 0 days
        - Grazing Feeding interval: Not allowed
        - REI: 24 hrs
        - Restricted use: No
        - Primary use: Bean leaf Beetle, Cutworm, Grasshopper, Green Cloverworm, Salt marsh Caterpillar, Woolly bear caterpillar

    - Carbofuran

        - Trade name and formulation: Furadan 4F, others
        - Use rates: 0.25-0.5 pts/Ac
        - Application: post emerge rescue
        - Pre-harvest interval: 21 days
        - Grazing Feeding interval: Not allowed
        - REI: 14 days
        - Restricted use: YES
        - Primary use: Grasshopper, Bean leaf beetle, soybean aphid

    - Thiodicarb

        - Trade name and formulation: Larvin 3.2
        - Use rates: NA
        - Application: NA
        - Pre-harvest interval: 28 days
        - Grazing Feeding interval: NO
        - REI: NA
        - Restricted use: No
        - Primary use: Bean leaf Beetle, Green Cloverworm,

- **Organophosphates**

    - Chloropyrifos

        - Trade name and formulation: Lorsban 4E
        - Use rates: 1-4 pts/Ac
        - Application: PPI, preplant, post emerge rescue
        - Pre-harvest interval: 28 days
        - Grazing Feeding interval: NO
        - REI: 24 hrs
        - Restricted use: No
        - Primary use: Bean leaf Beetle, Cutworm, Grasshopper, Green Cloverworm, Salt marsh Caterpillar, Woolly bear caterpillar, Spider mites, soybean aphid

- Methyl-parathion
    - Trade name and formulation: Penncap -M
    - Use rates: 2-3 pts
    - Application: NA
    - Pre-harvest interval: 20 days
    - Grazing Feeding interval: 20 days
    - REI: 48 hrs
    - Restricted use: Yes
    - Primary use: Bean leaf Beetle, Grasshopper, Green Cloverworm, Potato leafhopper, soybean aphid
- Phorate
    - Trade name and formulation: Phorate 20G/Thimet 20 G
    - Use rates: 9 oz/1000 ft/row
    - Application: band to side of seed at planting or 7inch band before press wheel. Do not allow to contact seed
    - Pre-harvest interval: 0 days
    - Grazing Feeding interval: NO
    - REI: 48 hrs
    - Restricted use: Yes
    - Primary use: Bean leaf Beetle, Seedcorn maggot
- Dimethoate
    - Trade name and formulation: Dimate. Dimethoate 4E
    - Use rates: 1 pt
    - Application: post emerge rescue
    - Pre-harvest interval: 21 days
    - Grazing Feeding interval: 5 days
    - REI: 24 hrs
    - Restricted use: Yes
    - Primary use: Bean leaf Beetle, Grasshopper, Potato Leafhopper, Spider mite
- Pyrethroids
    - Tralomethrin
    - Trade name and formulation: Scout-Xtra
    - Use rates: 1.7-3.4 fl oz/Ac
    - Application: Post emerge rescue
    - Pre-harvest interval: 21 days

        - Grazing Feeding interval: Not allowed
        - REI: 24 hrs
        - Restricted use: Yes
        - Primary use: Bean leaf Beetle, Cutworm, Grasshopper, Green Cloverworm

    - Lambda-cyhalothrin

        - Trade name and formulation: Warrior
        - Use rates: 1.92 – 3.84 fl oz/acre
        - Application: post emerge rescue
        - Pre-harvest interval: 45 days
        - Grazing Feeding interval: Not allowed
        - REI: 24 hrs
        - Restricted use: Yes
        - Primary use: Bean leaf Beetle, Cutworm, Grasshopper, Green Cloverworm, Salt marsh Caterpillar, Woolly bear caterpillar, Thistle caterpillar, Spider mite

    - Esfenvalerate

        - Trade name and formulation: Asana XL
        - Use rates: 2.9-5.6 fl. oz/Ac
        - Application: post emerge rescue
        - Pre-harvest interval: 21 days
        - Grazing Feeding interval: Not allowed
        - REI: 24 hrs
        - Restricted use: Yes
        - Primary use: Bean leaf Beetle, Cutworm, Grasshopper, Green Cloverworm, Potato leafhopper, Woolly bear caterpillar

    - Permethrin

        - Trade name and formulation: Ambush 2EC, Pounce 3.2 EC
        - Use rates: 3.2-6.4 fl. oz/Ac Ambush, 2-4 fl oz/Ac Pounce
        - Application: post emerge rescue
        - Pre-harvest interval: 45 days
        - Grazing Feeding interval: 14 days
        - REI: 24 hrs
        - Restricted use: Yes
        - Primary use: Bean leaf Beetle, Cutworm, Green Cloverworm, Potato leafhopper, Woolly bear caterpillar, Salt marsh caterpillar, Thistle caterpillar (see Ambush and Pounce label)

- Permethrin
    - Trade name and formulation: Barracuda, Kernal Guard Supreme, Assault 25, others
    - Use rates: see product label
    - Application: Seed treatment
    - Pre-harvest interval: 45 days
    - Grazing Feeding interval: 14 days
    - REI: 24 hrs
    - Restricted use: Yes
    - Primary use: Seed corn maggot, wireworm

- **Other**
    - Spinosad
        - Trade name and formulation: Tracer 4SC
        - Use rates: 1.5-2 fl. oz/Ac
        - Application: Post emerge rescue
        - Pre-harvest interval: 28 days
        - Grazing Feeding interval: Not allowed
        - REI: 4 hrs
        - Restricted use: No
        - Primary use: Green Cloverworm, Salt marsh Caterpillar
    - Dilubenzuron
        - Trade name and formulation: Dimilin 2L
        - Use rates: 2-4 fl oz/Ac
        - Application: Post emerge rescue
        - Pre-harvest interval: 21 days
        - Grazing Feeding interval: NO
        - REI: 12 hrs
        - Restricted use: No
        - Primary use: Green Cloverworm
        - Notes: Insect growth regulator
    - *Bacillus thuringiensis*
        - Trade name and formulation: Dipel ES, others
        - Use rates: 1-2 pts/Ac
        - Application: Post emerge rescue

- Pre-harvest interval: 0 days
- Grazing Feeding interval: 0 days
- REI: 0
- Restricted use: No
- Primary use: Green Cloverworm

Diseases

Overview

A serious problem for Minnesota soybean producers is underestimation of disease-incurred yield reduction. Diseases are second to weeds as the most common yield-limiting pest in soybean. Diseases can be characterized as seedling damping off/root rots, stem diseases, foliar diseases, virus diseases, and nematodes. Fungicides are most commonly used as seed treatments for seed-borne diseases and damping-off fungi. Although foliar fungicides are labeled for several foliar soybean diseases their cost prevents widespread use in many production situations

Root Rots

Seedling Root Blight: *Phytophthora spp.*
Stem Rot: *Phytophthora megasperma*

Symptoms include stand reduction, root rots, and basal stem decay Seed rot and pre-emergence damping-off are often credited to water damage. Taproots are usually dark brown, and small feeder roots are rotted or missing, on plants that survive the seedling phase. Stem discoloration, dark brown surface from the soil line up 6 inches, is less common on more tolerant/resistant varieties. Leaves on older plants become chlorotic, stunted and may wilt, turn brown, or die, and remain attached to the plant for some time. This fungus survives as an "oospore" in infected crop debris. The oospore germinates in wet soils and releases many "zoospores" that swim to developing soybean roots and infect. Disease and infection is favored by wet condition and soil temperatures near 60°F. Low-lying, poorly drained compact soils, or soils with high clay content, sites that are normally well-drained but wet, will increase disease severity. Resistant and field tolerant varieties are available. Single gene resistance is available for most races of *Phytophthora* but is often overcome within a field due to race shifts of the fungus.

Chemical control: Fungicide seed treatments containing metalaxyl, mefanoxam, oxydixyl
Seed borne:
Short crop rotation*: + (disease is worse under shorter soybean intercrop intervals)
Tillage to bury residue: Variety selection: + Resistance genes(rps) and field tolerance

Seed Decay, Seedling Blight and Root Rot
Pythium spp.

Seed rotted in soil, commonly soft, wet, and over-grown by other fungi are usually killed before emergence by this fungus. Rapid death prevents accurate diagnosis. Roots are brown, watery, soft and often completely decayed. Limited infection may produce brown lesions on roots, hypocotyl, or cotyledons. Death of meristem tissue may result in a swollen hypocotyl. These species are often referred to as "water molds" and survive in soil and in plant residue. Cool (50-60°F) temperatures and wet soils favor release of "swimming" spores with infection developing rapidly. Younger seedlings are most susceptible because soybeans become more resistant as they age.

Chemical control: Fungicide seed treatments containing metalaxyl, mefanoxam, oxydixyl
Seed born: -
Residue born: -
Soil born: +
Short crop rotation: + (disease is worse under shorter soybean intercrop intervals)
Tillage to bury residue: -
Variety selection: -

Post-emergence damage is more common than is pre-emergence death. Root symptoms are confined to lateral root decay and outer root surface damage only. A red-brown discoloration of the hypocotyls and lower stem does not extend above the soil line. Slow growing plants are damaged most, and symptoms, wilting, and death develop following warm, dry weather early in the season. This is another soil inhabitant that survives in soil as sclerotia or as "resting" mycelium in crop residue. Infection is favored by wet and cool conditions followed by warm and dry periods that stress the plant. Young plants are most susceptible, but stressed older plants may die if moisture is limited.

Chemical control: Fungicide seed treatments especially those containing PCNB, fludioxil or *Bacillus subtillus*
Seed born: -
Residue born:-
Soil born:+
Short crop rotation: + (disease is worse under shorter soybean intercrop intervals
Tillage to bury residue: -
Variety selection: -

Fusarium Root Rot
Fusarium oxysporum & *F. spp.*

A problem on seedlings and young plant roots that develop in wet, cool soils, below 58°F. Seedling growth can be slowed and plants usually are stunted and weak. Infection is often limited to lower tap

roots, and lower lateral roots which may be destroyed. New roots can develop from the upper tap- root providing a shallow fibrous root system that is prone to fail in dry soils. The vascular system can be affected, turns brown or black, and this increases late season plant wilt under moisture limiting conditions. This is perhaps the most common soybean root rot fungi in Minnesota. In addition to being a primary pathogen it often colonizes root systems weakened from other causes. Stress from soybean cyst nematodes, or other nematodes, and DNA herbicides predispose plants to infection. These soil born- fungi survive as chlamydospores and as mycelium in plant residues. Fusarium solani, reported to be the cause of Sudden Death Syndrome (SDS), has been reported from Minnesota, but isolates of this "Blue Strain" from Minnesota soils have not been confirmed to be like the isolates from Iowa or Illinois. Symptoms of SDS are interveinal chlorosis, necrosis, and leaf defoliation. Petioles remain firmly attached. The central pith (when sterns are split) should be white with no discoloration or decay. It is believed that certain isolates produce a toxin that trans locates to the upper leaves causing the above symptoms. Others report this fungus can be isolated from cyst nematodes.

Chemical control: Several fungicide seed treatments containing captan, especially in combination with PCNB + TBZ (Rival)

Seed born: -
Residue born: -
Soil born: +
Short crop rotation: + (disease may be worse under shorter soybean intercrop intervals)
Tillage to bury residue: -
Variety selection: ?

Stem Diseases

Brown Stem Rot
Phialophora gregata

Root infection precedes discoloration of water con- ducting vessels and at mid-season the vascular elements and stem pith show a reddish-brown color. The brown color develops first at the stem base and moves up, often most evident at nodes. Yield reduction increases with greater discoloration. Leaf symptoms develop later in the season. Look for wilt, interveinal browning and green tissue over the vein, leaf drying, and early leaf drop. Plants do not mature normally, and appear to be frost damaged. This fungus survivess in crop debris and increase inoculum levels are reported following tolerant varieties. Cool weather leads to more stem browning and warm dry conditions increase foliar symptoms, especially during the reproductive stage. Resistant and field tolerant varieties are available.

Chemical control: -
Seed born: -
Residue born:-

Soil born: +
Short crop rotation: +/- (disease may be worse under shorter soybean intercrop intervals
Tillage to bury residue: +
Variety selection: Resistance gene and field tolerance

Pod and Stem Blight and Seed Decay
Diaporthe phaseolorum var.sojae

Linear rows of brown to black fruiting bodies, "pycnidia," are seen on stems, but are scattered on pods. Infection of healthy plants is common, but the pycnidia are produced only on dead or dying tissue. Seeds in infected pods have a white, moldy growth, are wrinkled, smaller, and germinate poorly. Seed infection tends to be greater when warm wet or humid weather delays harvest. Plants that are killed early, or plants that are harvested late in wet or warm humid late summer, often have pycnidia present. Infected seed can produce infected plants, but most infection comes from inoculum in infested crop residue. Spores splash on plants during wet weather and infection is favored by injuries, hail, or lesions caused by other pathogens.

Chemical control: Foliar fungicides containing benomyl, chlorothalonil, triophanate-methyl
Seed born: +
Residue born:+
Soil born: -
Short crop rotation: + (disease may be worse under shorter soybean intercrop intervals)
Tillage to bury residue: -
Variety selection: vary in susceptibility

Anthracnose
Colletotrichum truncatum & C. destructivum

Symptoms appear at early reproductive stages on stems, pods, and petioles. Watch for leaf rolling, petiole cankers, veinal necrosis, and early leaf drop. Stem and pods have black fruiting bodies, "acervuli," with black hairs, "setae." Seed are shriveled, moldy, and stained brown or dark. Early season infection can be from seed inoculum, while infection during flowering is mostly from infected plant residue. High plant populations and wet canopies favor disease development.

Chemical control: Foliar fungicides containing benomyl, chlorothalonil, triophanate-methyl
Seed born: +
Residue born: +
Soil born: -
Crop rotation: + (disease may be worse under shorter soybean intercrop intervals)
Tillage to bury residue: +
Variety selection:

Sclerotinia

Stem Rot
Sclerotinia sclerotiorum

Flower petals are infected and mycelium colonizes the stem and pods. Stem tissue becomes tan or white and may be covered with white mycelium and black sclerotia (round, oblong, hard, black structures). The top of the plant dies and turns brown. This is often the first symptom observed. Stem lesions may increase lodging. Sclerotia on the stem fall to the ground and others inside the pith are released when seed is harvested. Sclerotia can be found with the seed. The fungus survives winter as sclerotia and can remain alive in soil for many years. Sclerotia germinate in warm/wet spring, summer, or fall periods and release spores that are wind-borne. Soybean infection requires moisture on the flower petals, and is favored by closely spaced plants that form an early dense canopy. Varieties vary in susceptibility.

Chemical control: Foliar fungicides triophanate-methyl. The herbicide lactofan has been observed to suppress this disease. Seed treatments containing fludoxinil or TBZ or carboxin can control seedborn infections.
Seed born: + (Not a major epidemiological factor)
Residue born: -
Soil born: +
Short crop rotation: - (persistent sclerotia reduce the effectiveness of a single non-host crop between soybean crops)
Tillage to bury residue: - (may affect one rotational cycle only)
Variety selection: + (varieties vary in susceptibility)

Stem Canker
Diaporthae phaseolorum var caulivora

Infection symptoms develop during early reproductive stages at nodes as a small red-brown lesion. Over time, the lesion expands, forming a darker brown, elongated sunken canker. Leaf tissue yellows between the veins and with reduced water flow death of leaves is common. At times, top growth ceases and a shepherd's crook curl develops. Girdling and toxin production are responsible for symptoms and death. Symptoms in Minnesota often are field and seedlot specific, and may have resulted from seed contamination. However, the fungus is reported to survive on infested debris. Most soybean cultivars can be infected, but only those that are susceptible allow the disease to develop.

Chemical control: Foliar fungicides containing benomyl, chlorothalonil, triophanate-methyl
Seed born: +
Residue born: +

Soil born: -
Short crop rotation: + (disease may be worse under shorter soybean intercrop intervals)
Tillage to bury residue: ?
Variety selection: ? (Varieties differ in amount of disease progression allowed)

Foliar diseases

Bacterial Blight
Pseudomonas syringae

Small, angular, water-soaked spots on leaves turn red-brown to black as tissue dies and dries. Spots may have a water-soaked margin and a yellow halo. As leaves grow and flex, dead tissue falls out, and leaves may appear tattered and ragged. Seed may be colonized, becoming shriveled with sunken, discolored lesions. Wind-driven rains spread infected soybean residue or seed borne innoculum to plants. Early infections may appear severe, especially in wet weather, but hot dry conditions stop disease development.

Chemical control: -
Seed born: +
Residue born: -
Soil born: +
Short crop rotation: + (disease may be worse under shorter soybean intercrop intervals)
Tillage to bury residue: -
Variety selection:

Brown Spot
Septoria glycines

Brown spot is primarily an early season leaf disease. Cotyledons, primary leaves and lower trifoliolates show brown to red pinpoint spots up to 1/4 inch. Some may grow together and become irregularly shaped spots. Look for black dots, "pycnidia," in center of mature spots. Severe infection can cause leaves to yellow and drop early, especially the lower canopy. Spores are splashed or wind blown to wet leaves, mostly in mid- spring. It can develop in warm moist periods at any time. Hot, dry weather stops this disease, but it can resume development before plants mature.

Chemical control: Foliar fungicides containing benomyl, chlorothalonil, triophanate-methyl
Seed born: -
Residue born: +
Soil born: -
Short crop rotation: + - (disease may be worse under shorter soybean intercrop intervals)

Tillage to bury residue: +
Variety selection: ?

Purple Seed Stain and Leaf Blight
Cercospora kikuchii

Seed discoloration varies from pink to pale or dark purple and the area affected ranges from specks to blotches, possibly the entire seed coat. Infected seed may not show symptoms, but infected cotyledons shrivel, turn dark purple, and drop early. Plants can be killed or stunted. This fungus survives as mycelium on the seed coat or on crop residue. Spores from infected seed cotyledons are splashed or wind- borne to leaves and stems. Small, red-purple, angular lesions develop on both sides of sun-exposed upper leaves during seed set. Leaf symptoms begin as a light purple color that extends over the leaf and develops a leathery appearance. Infection is favored by high temperatures (80°F plus) and humid conditions.

Chemical control: Foliar fungicides containing benomyl, chlorothalonil, triophanate-methyl
Seed born: +
Residue born: +
Soil born: -
Short crop rotation: + (disease may be worse under shorter soybean intercrop intervals)
Tillage to bury residue: +
Variety selection:

Downy Mildew
Peronospora manshurica

Pale green to light yellow spots on the upper surface of young leaves which, may enlarge, forming bright yellow lesions of indefinite size. Older infected spots turn gray-brown. Spots on the lower leaf surface, especially in moist weather, have tufts of gray mycelium and spores easily seen with a lens. Older leaves are more resistant, but young leaves are susceptible. Pods may be infected with- out any symptom, and seeds are partly or completely covered by white mycelia and oospores, which are easy to see. Seed from infected pods may be smaller and have cracks in the seed coat.

Chemical control:
Seed born: +
Residue born: +
Soil born: -
Short crop rotation: + (disease may be worse under shorter soybean intercrop intervals)
Tillage to bury residue: +
Variety selection: ? (vary in susceptibility)

Powdery Mildew
Microsphaera diffusa

White powdery patches of mycelia and conidia are seen on all above-ground plant parts.

Additional symptoms develop on some susceptible varieties, such as chlorosis, green islands, rusty patches, and defoliation. Disease develops in cooler than normal years with reduced plant growth.

Chemical control:
Seed born: -
Residue born: -
Soil born: -
Short crop rotation:
Tillage to bury residue: -
Variety selection: Varieties differ in susceptibility

Viral Diseases

A large numbers of viruses infect plants, and soybeans, have more than a hundred virus or virus strains reported. New virus problems are expected as soybean seed production occurs in many new environments.

Soybean Mosaic Virus or Crinkle

Infected plant leaves are spindly, narrower than normal, have dark green swellings along veins. Plants are stunted and petioles are short, as are the internodes. Infected pods are small, flat, have less hair, and are curved more. Seed germination may be reduced. This virus is seed-borne, can overwinter in perennial weeds, and is spread by aphid species.

Chemical control: - (Unknown effect of controlling aphid vector)
Seed born: +
Crop rotation: -
Tillage to bury residue: -
Variety selection: ?

Bean Pod Mottle

A mild-yellow mottling is seen on the youngest leaves during rapid growth in cool weather. The mottle

disappears as plants mature and plants may be slightly stunted, with distorted foliage, misshapen pods, and smaller seeds. The virus overwinters in legumes, clover, or alfalfa and is spread by insect feeding; especially the bean leaf beetle. Symptoms are masked by high temperatures, and are not seen after pod set.

Chemical control: - (Unknown effect of controlling bean leaf beetle vector)
Seed born: +
Short crop rotation: -
Tillage to bury residue:-
Variety selection: ?

Nematodes

Large numbers of nematodes exist in soils, but only a few are of economic importance on soybeans. Nematode damage can be direct and/or indirect. Soybean nematode damage is significant and difficult to accurately diagnosis without proper sample collection, including soil and root samples.

Cyst Nematode
Heterodera glycines

Low levels of infection can remain undetected for some time as diagnostic above ground symptom are minimal. Stunted, chlorotic, vigor less beans with reduced root systems and few nitrogen nodules are typical of low infection levels in high fertility sites. Egg numbers do increase and symptom severity increases, reducing soybean yields. Carefully dig and examine roots for white to tan females containing eggs any time after late June through September. Soil movement on equipment, or with water or wind spreads the cysts. Birds can carry the cysts considerable distances. Most southern Minnesota farms have some level of infestation. Extending the rotation between soybean crops and soybean cyst nematode resistant varieties are recommended management practices. Although Temik, Vydate and Telon nematicides are registered they provide inconsistent results, are expensive and are therefore not currently recommended.

Chemical control: Not currently recommended Temik, Vydate, Telon
Seed born: - (may be carried in soil bed contaminated seed lots)
Short crop rotation: - (persistent cysts and eggs reduce the effect of a single non host crop between soybean crops a prolonged period between hosts will reduce SCN populations)
Tillage to bury residue: - (tillage equipment can spread SCN within and between fields)
Variety selection: SCN resistant varieties are available

Lesion Nematode
Pratylenchus spp.

Lesion nematodes are found worldwide. They attack the root cortex. Roots develop dark lesions and an overall brown color. Loss of the epidermis and cortex decreases root growth nutrient and water uptake. Under stress, plants yellow, become stunted, and have reduced yields.

Sting Nematode
***Belonolaimus spp*.**

Seedlings can be killed, reducing stands. Larger plants are not killed, but appear stunted, chlorotic, and gray-green as if moisture deficient. Small, dark, sunken lesions are present on roots to the tip. Terminal root growth stops and roots appear stubby or have abnormal root proliferation. Damage is usually found in sandy soils. Sting nematodes feed on many host plants, especially grasses, and can also attack corn.

*short rotation is defined here as one year of non –host crop between soybean crops

Other pathogens of soybean reported from Minnesota include:

Alternaria leaf spot:	*Alternaria spp.*
Bacterial blight:	*Pseudomonas syringae*
Bacterial pustule:	*Xanthomonas campestris*
Charcoal rot:	
Frogeye leaf spot:	*Cercospora sojina*
Phomopsis seed rot:	*Phomopsis spp*. See Pod and Stem Blight, Stem canker, Anthracnose
Phyllostica leaf spot:	*Phyllostica sojicola*
Target spot:	
Alfalfa mosaic virus	
Tobacco ringspot virus	

Soybean Fungicide Information

- **Captan**
  - Trade name and formulation: various
  - Percent crop treated: Not available
  - Use rates: 0.62-1.18 oz/100 lbs. seed
  - Application timing: seed treatment
  - REI: 96 hrs
  - Component of other products: several
  - Primary use: seed rots and seedling blights (*Pythium, Phytophthora, Rhizoctonia*)
- **Metalaxyl**
  - Trade name and formulation: Apron 50W, Ridomil
  - Percent crop treated: Not available
  - Use rates: 0.032 - 0.5 oz ai/100 lbs seed
  - Application timing: seed treatment
  - REI: 12 hrs
  - Component of other products: Apron MAXX
  - Primary use: seed rots and seedling blights (*Pythium, Phytophthora*)
- **Mefenoxam**
  - Trade name and formulation: Apron XL
  - Percent crop treated: Not available
  - Use rates: 0.16-0.64 fl. oz/100 lbs seed
  - Application timing: seed treatment
  - REI: 12 hrs
  - Component of other products: several seed treatment mixtures
  - Primary use: seed rots and seedling blights (*Pythium, Phytophthora*)
- **Oxadixyl**
  - Trade name and formulation: Anchor
  - Percent crop treated: Not available
  - Use rates: 1.5-2.25 fl. oz/100 lbs seed
  - Application timing: seed treatment
  - REI: NA
  - Component of other products:
  - Primary use: seed rots and seedling blights (*Pythium, Phytophthora*)

- **Fludioxonyl**
    - Trade name and formulation: Maxim
    - Percent crop treated: Not available
    - Use rates: 0.08-0.16 fl oz/100lbs. seed
    - Application timing: seed treatment
    - REI: NA
    - Component of other products: Apron MAXX, other seed treatment mixtures
    - Primary use: seed rots and seedling blights
- **Carboxin**
    - Trade name and formulation: Vitavax 34 and others
    - Percent crop treated: NA
    - Use rates: see label
    - Application timing: seed treatment
    - REI: NA
    - Component of other products: mixed with other seed treatment fungicides and insecticides
    - Primary use: seed rots and seedling blights
- **PCNB**
    - Trade name and formulation: various
    - Percent crop treated: NA
    - Use rates: see label
    - Application timing: seed treatment
    - REI: NA
    - Component of other products: Rival (PCNB+Captan+Thiobendazole) and mixed with other seed treatment fungicides
    - Primary use: seed rots and seedling blights
- **Thiobendizole (TBZ)**
    - Trade name and formulation: various
    - Percent crop treated: NA
    - Use rates: See label
    - Application timing: seed treatment
    - REI: NA
    - Component of other products: Rival (PCNB+Captan+Thiobendazole) and mixed with other see treatment fungicides
    - Primary use: seed rots and seedling blights

- **Thiram**
    - Trade name and formulation: various
    - Percent crop treated: NA
    - Use rates: see label
    - Application timing: seed treatment
    - REI: 24
    - Component of other products: mixed with other see treatment fungicides
    - Primary use: seed rots
- ***Bacillus subtilus***
    - Trade name and formulation: Kodiak
    - Percent crop treated: NA
    - Use rates: 1-16 oz/100 lbs seed
    - Application timing: seed treatment
    - REI: NA
    - Component of other products:
    - Primary use: seedling blights and root rots especially Rhizoctonia
- **Chloroneb**
    - Trade name and formulation: Chloroneb 65W
    - Percent crop treated: NA
    - Use rates: 4 oz/100 lbs seed
    - Application timing: seed treatment
    - REI: NA
    - Component of other products:
    - Primary use: seedling blights
- **Benomyl**
    - Trade name and formulation: Benlate
    - Percent crop treated: NA
    - Use rates: 0.5 lb ai/Ac
    - Application timing: postemergence, after early pod-set. Repeat 14-21 days later (as needed)
    - Pre-harvest interval: 35 days, do not graze or feed treated vines to livestock.
    - REI: 24 hrs
    - Component of other products: NA
    - Primary use: pod and stem blight, anthracnose, stem canker, Septoria brown spot, purple seed stain.

- **Chlorothalonil**
    - Trade nam and formulation: Bravo 500
    - Percent crop treated: NA
    - Use rates: 0.78-1.82 lb ai/Ac per application
    - Application timing: postemergence; 2 or 3 applications at 7day intervals.
    - Pre-harvest interval: Do not apply within 6 weeks of harvest. Do not feed soybean hay or residue to livestock.
    - REI: 48 hrs
    - Component of other products: NA
    - Primary use: pod and stem blight, anthracnose, stem canker, Septoria brown spot, purple seed stain.

- **Thiophanate-methyl**
    - Trade name and formulation: Topsin-M
    - Percent crop treated: Not available
    - Use rates: 0.35 - 0.7 lb ai/Ac per application - two applications maximum per season.
    - Application timing: NA
    - Pre-harvest interval: Do not apply after beans begin to form in pods. Do not graze or feed treated vines or hay to livestock.
    - REI: 12 hrs
    - Component of other products: NA
    - Primary use: pod and stem blight, anthracnose, stem canker, Septoria brown spot, purple seed stain.

Weeds

Weeds growing with soybeans compete with the crop for light, moisture, and nutrients. Uncontrolled, weeds reduce soybean yields and interfere with harvest. A 1992 report of the Weed Science Society of America estimated that weeds cause more than a $52 million loss in Minnesota soybean production each year. An effective weed management program requires understanding potential weed problems, and planning, to control weeds in a timely manner. Soybeans are very competitive with weeds once the soybeans develop a canopy, but early emerging weeds, if left uncontrolled, can cause significant yield loss. Early season weed control (generally before weeds reach 4 inches in height) is the key to providing soybeans with a competitive advantage by minimizing the impact of weeds. The most effective control programs include a variety of control practices in an integrated weed management system.

Common Weed Problems in Minnesota Soybean Fields

Annuals:

Summer annual grass and broadleaf weeds such as foxtails, woolly cupgrass, tall water-hemp, common ragweed, and common cocklebur can be problems in soybeans. These weeds germinate in the spring and summer and produce seed before they die in the fall. A well-timed cultivation or herbicide treatment can greatly reduce annual weed populations. Annual weeds have a fairly predictable pattern of emergence, but their germination depends on soil moisture and temperature. Please refer to the Iowa State University, Leopold Center publication, Relative Emergence Sequence for Weeds of Corn and Soybeans for more details. This publication can be ordered from the University of Minnesota Extension Service Distribution Center as FO-6958 at no charge. Several annuals tend to drive weed control decisions for producers. Primary among these are yellow foxtail, common ragweed and common lambsquarters due to difficulties in chemical control and waterhemp due to its extended emergence window.

Important annual grasses:	**Important annual broadleaves:**
Foxtails: yellow, green*, and giant	Common cocklebur*
Woolly cupgrass	Common sunflower
Wild proso millet	Common ragweed
Barnyard grass	Giant ragweed
	Velvet leaf
	Pigweeds (redroot*, common waterhemp*)
	Black nightshade
	Pennsylvania smartweed
	Wild buckwheat
	Common lambsquarters*

* denotes species with known herbicide resistance in MN

Winter Annuals and Biennials

Winter annual weeds such as mustards and horseweed (marestail), and annual/biennial weeds such as biennial wormwood, can be a problem in no-till soybeans. These weeds germinate in the fall and become a noticeable problem by early to mid-summer of the next growing season. They can be controlled with tillage or burndown herbicide treatments before soybean planting.

Perennials

Perennial weeds originating grow an established rhizome or root system are very competitive and difficult to control. Perennial broadleaf weeds such as Canada thistle, common milkweed, and hemp dogbane are difficult to manage in soybeans. Spot spraying, weed wipers, or herbicide resistant crops tolerant to nonselective herbicides such as Roundup will help manage these perennial broadleaf weeds. Crop rotation or fall treatment best manages these weeds after soybean removal.

Weed Identification

Proper weed identification is the foundation of a successful weed management program. Being able to identify weeds at the seedling stage of development is a critical component of profitable soybean production because with weed control, timing is everything. We have included in this section the unique broadleaf weed seedling and grassy weed seedling identification keys created by Dr. Beverly Durgan, University of Minnesota.

Integrated Weed Management

Effective weed control usually results from a combination of cultural, mechanical, and chemical practices. The ideal combination for each field will depend on a number of considerations including:

1. Type of weeds present
2. Level of weed infestation
3. Soil type
4. Cropping system
5. Availability of time and labor to complete the control tactic in a timely manner

Weed-Soybean Competition

Weeds can be vigorous competitors with soybeans and typically germinate and emerge with soybeans. Soybeans are susceptible to shading from taller weeds which also compete for nutrients and water. Since soybeans are especially sensitive to moisture deficiencies in early to mid summer, complete weed control must be accomplished within four to five weeks following soybean emergence in order to avoid yield losses due to early emerging weeds. Planting narrow rows and following production practices that encourage vigorous soybean growth will increase the crop's competitive advantage over weeds. The idea is to shade out late emerging weeds. In wide row spacing, a producer should strive to have the soybeans lapped in the row middles as soon as possible. Generally, weeds that emerge four to five weeks after the soybeans' planting date will not be competitive with the crop.

Crop Rotation Practices

Crop rotation can be an important component of a weed management program. For example, most annual broadleaf weeds can be more easily and economically managed in corn than in soybeans. The opposite is true for most annual grass weeds. Crop rotation can encourage (over time) the use of

different types of herbicides, with different sites of action. This helps to prevent the development of herbicide resistant or tolerant weeds. See "Herbicide Resistant Weeds", FO-6077, University of Minnesota Extension Service Distribution Center.

Tillage Practices

Several tillage practices aid weed management in soybean. Seedbed preparation prior to planting can kill weeds which have germinated. In the absence of seedbed tillage, a burndown herbicide treatment is often required. Killing the weeds that germinate prior to, or at the time of soybean planting, regardless of the tillage system employed, is important because these will be the most competitive weeds. For pre-emergence herbicides to be effective, they must be moved into the soil by rainfall before the weed seeds germinate. If rainfall has not been sufficient for herbicide activation, the weed seedlings should be controlled with a rotary hoe or harrow as soon as they emerge. Cultivation of weed escapes is also an effective and economical weed control tool. Cultivation should be done when weeds are small (<1 inch) and cultivation should be shallow (1-2 inches) to avoid soybean root damage.

Herbicides

Herbicides are used on almost all soybean acreage because they have proven to be an efficient weed management tool. NASS data (1) indicates that 97-99% of soybean acreage received herbicide treatments during 1995-98. Far too many growers, however, equate weed management solely with herbicides. University of Minnesota research trials indicate weed management is most consistently successful and economical when a diversity of weed management tools are used in an integrated approach. For example, cultivation following a planned herbicide application or a sequential pre-plant incorporated/post-emergence herbicide program is more consistently successful than a one-pass post-emergence weed control program. Also, a more diversified weed management approach will prevent weed species shifts.

Selecting Herbicides

Selection of an appropriate herbicide or combination of herbicides should be based on consideration of the following factors: label approved for use, ground/surface water pollution concerns, use of the crop, crop and variety tolerance, potential for soil residue which may affect subsequent crops, weed type, soil texture/pH/organic matter, potential for drift problems, tillage practices, herbicide performance and cost, and availability of a fully-adapted herbicide-resistant crop.

Timing

Proper application of chemicals is essential for obtaining satisfactory results. Follow suggested rates on the label for specific soil and weed situations. Apply herbicides at the weed and crop stages specified. Delayed applications usually result in poor weed control and may injure the crop.

Weather

Weather conditions, including temperature and humidity, will affect herbicide performance. Temperatures <50° F and >90° F often limit the soybean's ability to degrade the herbicide, and application outside that range may result in crop injury. Dry soil conditions or cold temperatures (<50° F) may limit the ability of weeds to take up enough herbicide to provide adequate control. Heavy rainfall can move a herbicide downward into the soil resulting in poor control or crop injury. When applying herbicides, observe label precautions regarding weather conditions as well as those pertaining to crop and weed size.

Early Pre-Plant Treatment

Emerged weeds must be controlled at planting for soybeans to be successful. Certain herbicides can be applied before the beans are planted in the spring to control emerged weeds, and/or for residual control of late-emerging weeds. Many residual herbicides applied early need to be applied before weeds germinate. They usually require precipitation or incorporation for herbicide activation. If weeds have already emerged at treatment time in no-till planted fields, the addition of a bum-down herbicide with foliar activity is often required. Early pre-plant herbicides need enough residual activity to control weeds before and after planting, or they may require follow up treatments of post-emergence herbicides, or cultivation.

Pre-Plant Incorporated Herbicides

Certain residual herbicides can be applied and incorporated into the soil prior to planting to control susceptible weeds. These pre-plant herbicides need to be incorporated thoroughly to the proper soil depth, as per label instructions. Incorporation is more uniform with dry, mellow soil than with damp, cloddy soil. Pre-plant-incorporated herbicides are less dependent on rainfall for their effectiveness because they have been mechanically placed in the weed emergence zone. Avoid furrowing too deep at planting, and thereby moving too much treated soil out of the planted row.

Pre-Emergence Herbicides

Some residual herbicides can be applied to the soil surface after the crop is planted, but before soybean and weed emergence. Rainfall or irrigation of 0.5-0.75" water is required after application to move the herbicide into the soil where it can be absorbed by the germinating weeds. Too little or too much rainfall after herbicide application can cause poor weed control. In Minnesota, south-central and southeastern sections of the state have the greatest probability of timely rainfalls that will successfully activate pre-emergence herbicides. In southwestern, west central, and northwestern Minnesota, the probability of such a timely rainfall is lower, and pre-plant incorporated herbicides tend to be the more effective soil-applied herbicide option. Also, if there is insufficient rain, a rotary hoe can be used to control small weeds and help incorporate the herbicide.

Pre-emergence herbicides can also be applied in a band over the row at planting. Band applications are generally 12-14" wide. With a planned cultivation after crop emergence to control weeds between the rows, banding provides an opportunity to reduce herbicide inputs without sacrificing yields.

Post-Emergence Herbicides

Post-emergence herbicides control weeds after the crop and weeds have emerged from the soil. Some post-emergence herbicides have soil residual activity (e.g. Pursuit) while others do not (e.g. Roundup Ultra). Application rate, weed and crop size, environmental conditions, and adjuvants (effectiveness enhancements) greatly influence post-emergence herbicide performance. Post-emergence herbicides are most effective when applied to small weeds that are actively growing. Application to larger weeds or plants growing under environmental stress may result in poor weed control and increased crop injury. In Minnesota, it takes approximately four weeks for an annual weed such as giant foxtail to reach four inches in height. In five weeks, giant foxtail can be five to six inches tall, and in six weeks the foxtail may be eight inches tall. For many herbicides the ideal foxtail height for post-emergence application is three to four inches. Therefore, the window of opportunity for effective post-emergence control is approximately one week. Many post-emergence herbicides require adjuvants to improve plant uptake. However, using the wrong adjuvant under the wrong environmental conditions can increase herbicide crop injury potential. Only use adjuvants according to herbicide label recommendations.

Herbicide Mode of Action

Herbicide mode of action is the process by which herbicides kill weeds. Different herbicides can affect different plant processes, resulting in the death of the weed (not the soybeans). Herbicide mode of action is also a convenient way to categorize the numerous herbicides in the marketplace. Herbicides can be classified into families based on their chemical similarity. In some cases, herbicides from different families target the same biochemical process (site of action) within the plant and result in the same herbicide crop injury response in the plant. Herbicide mode of action explains how herbicides kill plants, and herbicide site of action tells you what plant process is affected.

Learning herbicide mode of action processes will help you understand the events that relate to herbicide effectiveness. For example, temperature can influence the effectiveness and crop injury potential of a particular herbicide. Understanding herbicide mode of action will improve: 1) crop injury diagnostic skills, 2) herbicide selection and application skills, 3) herbicide resistance management strategies. See the *"Herbicide Mode of Action and Crop Injury Symptoms"* publication for more details. This publication can be ordered from the University of Minnesota Extension Service Distribution Center as BU-3832.

Herbicide Resistant Weeds

Weed species vary in susceptibility to herbicides. A population that is initially susceptible to a herbicide but contains a small percentage of resistant biotypes may develop into a resistant population. Selection

for resistance is most likely with the repeated use of a highly effective herbicide program. It is important to use different weed management tactics (e.g. herbicides, cultivation, rotary hoeing, crop rotation) that affect different sites of action in the target weeds. See the *"Herbicide Resistant Weeds"* publication for more details. This publication can be ordered from the University of Minnesota Extension Service Distribution Center as FO-6077.

Herbicide Resistant Soybeans

Herbicide resistant soybeans allow the use of herbicides that would otherwise seriously injure or kill the soybeans. Herbicide resistant soybeans that have been developed include STS soybeans (for use with Reliance STS) and Roundup Ready soybeans (for use with Roundup Ultra) Reliance STS is a broadleaf herbicide and Roundup Ultra is a broad-spectrum herbicide with grass and broadleaf weed activity. STS soybeans were developed by conventional breeding techniques. Roundup-Ready soybeans were developed through genetic engineering. Since their introduction in Minnesota, Roundup-Ready soybeans, and as a result Roundup herbicide, have captured a large share of the planted acres. As with any weed management practice, use of an herbicide resistant crop, and the corresponding herbicide, should be part of an integrated weed management program.

Soybean Herbicides

No-Till or Minimum Till Herbicides

In no-till or minimum till soybean production, herbicides may be required to control or suppress emerged weeds. Glyphosate (Roundup formulations, Touchdown) or paraquat (Gramoxone Max) are non-selective herbicides that will kill emerged weeds. These herbicides have no soil activity and are usually tank-mixed with other herbicides that provide residual control of later-germinating weeds.

Preplant Incorporated or Pre-Emergence Applications

Several herbicides including alachlor (Lasso), dimethenamid, (Frontier, Outlook), flufenacet + metribuzin (Domain), metolachlor (Dual II Magnum), and metribuzin (Sencor) are suggested for use either preplant incorporated or pre-emergence. These herbicides may be left on the soil surface or incorporated with one or two tillage operations. Preplant incorporated applications of these herbicides are most effective when there is inadequate rainfall to activate pre-emergence applications. However, pre-emergence applications provide more effective weed control when adequate rainfall does occur. If weed seedlings begin to emerge following a pre-emergence application, due to lack of rainfall, an early harrowing, rotary hoeing, or shallow cultivation will improve weed control

Postemergence Applications

Weeds are much easier to control postemergence when they are young. This is especially true under

adverse environmental conditions and with certain weed species, such as velvetleaf and lambsquarters. For example, a split application of Basagran at 1 pt/A approximately two weeks after soybean planting followed by 1 pt/A 10-14 days later, if necessary, can be quite effective and economical. Basagran is more effective if applied to young weeds. Often, removing the first flush of weeds is all that is necessary, because later weed flushes can be cultivated or may be shaded out by the soybeans. See the label for more detailed instructions and maximum allowable weed heights and leaf stages.

Herbicide additives such as surfactants, petroleum (crop) and vegetable oils, stickers, and fertilizers (28% N, 10-34-0, ammonium sulfate) often increase weed control. Misuse of additives can often result in crop injury. For example, the addition of oil concentrate to Blazer (acifluorfen), Cobra (lactofen), or Reflex (lactofen) increases the potential for soybean injury.

- **ALS-inhibitors and amino acid derivatives**
    - **Chloransulam methyl**
        - Trade name and formulation: FirstRate 84WDS
        - Percent crop treated: NA
        - Use rates: 0.016-0.039 lbs ai/Ac
        - Application timing: PPI, pre-emergence, postemergence before soybean bloom
        - Pre-harvest interval: 65 days. May harvest for forage or hay after 14 days.
        - REI: 12 hrs
        - Component of other products: Gauntlet
        - Primary use: Annual broadleaves especially composites
    - **Chlorimuron**
        - Trade name and formulation: Classic 25DF
        - Percent crop treated: 4
        - Use rates: 0.008-0.012 lbs ai/Ac
        - Application timing: postemergence (Classic, Synchrony)
        - Pre-harvest interval: 60 days. Do no graze or feed treated forage.
        - REI: 12 hrs
        - Component of other products: Synchrony STS
        - Primary use: Annual broadleaves
    - **Flumetsulam**
        - Trade name and formulation: Python 80WDG/Broadstrike
        - Percent crop treated: NA
        - Use rates: 0.04-0.07 lb ai/Ac
        - Application timing: preplant incorporated, pre-emergence (apply 30 days prior to

planting until before the soybean cracking stage)
- Pre-harvest interval: 85 days
- REI: 12 hrs
- Component of other products: Broadstrike + Treflan
- Notes: Do not apply to soils <5.9 pH and >5% organic matter or to soils >7.8 pH
- Primary use: Annual broadleaves

- **Imazamox**

  - Trade name and formulation: Raptor 1AS
  - Percent crop treated: 26
  - Use rates: 0.03-0.04 lb ai/Ac
  - Application timing: postemergence up to 5 inch weed height but prior to soybean bloom)
  - Pre-harvest interval: 85 days. Do not graze or feed treated soybean forage, hay, or straw to livestock.
  - REI: 4 hrs
  - Component of other products: NA
  - Primary use: Annual broadleaves and annual grasses

- **Imazaquin**

  - Trade name and formulation: Scepter 70DG, Scepter 1.5AS
  - Percent crop treated: NA
  - Use rates: 0.047- 0.063 lb ai/Ac
  - Application timing: preplant incorporated, pre-emergence (up to 45 days before planting), postemergence
  - Pre-harvest interval: 90 days. Do not graze or feed treated soybean forage, hay or straw to livestock.
  - REI: 12 hrs
  - Component of other products: NA
  - Primary use: Annual broadleaves
  - Notes: South of Highway 210 only. Several rotational restrictions Soil applications most restrictive

- **Imazethapyr**

  - Trade name and formulation: Pursuit 70DG
  - Percent crop treated: 27
  - Use rates: 0.047 - 0.0625 lb ai/Ac
  - Application timing: postemergence - apply to weeds less than 3 inches in height
  - Pre-harvest interval: 85 days. Do not graze or feed treated soybean forage, hay or

straw to livestock.
        - REI: 4 hrs
        - Component of other products: Pursuit Plus, Extreme
        - Primary use: Annual broadleaves and annual grasses

    - **Thifensulfuron**

        - Trade name and formulation: Pinnacle 25DF, Harmony GT
        - Percent crop treated: 8
        - Use rates: 0.004 lbs ai/Ac
        - Application timing: postemergence after 1st trifoliate has expanded
        - Pre-harvest interval: 60 days. Do not graze or feed treated forage.
        - REI: 12 hrs
        - Component of other products: Synchrony STS
        - Primary use: Annual broadleaves

- **ACC-ase inhibitors**

    - **Clethodim**

        - Trade name and formulation: Select 2EC, Prism
        - Percent crop treated:
        - Use rates: 0.06-0.25 lb ai/Ac
        - Application timing: postemergence
        - Pre-harvest interval: 60 days. Do not graze or feed treated forage or hay to livestock.
        - REI: 12 hrs
        - Component of other products:
        - Primary use: Annual and perennial grasses
    - **Fenoxaprop**

        - Trade name and formulation:
        - Percent crop treated: 5
        - Use rates: 0.026 - 0.035 lb ai/Ac
        - Application timing: postemergence prior to soybean bloom
        - Pre-harvest interval: none. Do not graze or feed treated forage or hay to livestock.
        - REI: 24 hrs
        - Component of other products: Fusion 2.66EC
        - Primary use: Annual and perennial grasses
    - **Fluazifop**

        - Trade name and formulation: Fusilade DX 2EC

        - Percent crop treated: 6
        - Use rates: 0.09-0.19 lb ai/Ac
        - Application timing: postemerge until soybean bloom
        - Pre-harvest interval: none. Do not graze field or harvest for forage or hay.
        - REI: 12 hrs
        - Component of other products: Fusion 2.66EC
        - Primary use: Annual and perennial grasses

    - **Quizalofop**

        - Trade name and formulation: Assure II 0.8EC
        - Percent crop treated:
        - Use rates: 0.03-0.06 lb ai/Ac
        - Application timing: postemerge until pod set
        - Pre-harvest interval: 80 days. Do not graze field or harvest for forage or hay.
        - REI: 12 hrs
        - Component of other products:
        - Primary use: Annual and perennial grasses
    - **Sethoxydim**

        - Trade name and formulation: Poast Plus 1EC, Prestige 1EC, Poast 1.5EC
        - Percent crop treated: 3
        - Use rates: 0.09-0.38 lb ai/Ac
        - Application timing: postemergence
        - Pre-harvest interval: 75 days. Do not graze treated fields. Do not feed treated forage (green/succulent) or silage to livestock. Treated hay may be fed.
        - REI: 12 hrs
        - Component of other products: Conclude, Rezult
        - Primary use: Annual grasses and perennial grasses

- **PSII inhibitors (non-mobile)**

    - **Bentazon**

        - Trade name and formulation: Basagran 4S
        - Percent crop treated: 4
        - Use rates: 0.5-1.0 lb ai/Ac
        - Application timing: postemergence
        - Pre-harvest interval: no restriction. Do not graze or cut for forage or hay for at least 30 days after last treatment.
        - REI: 48 hrs
        - Component of other products: Galaxy, Storm, Conclude, Manifest, Rezult B

        - Primary use: Annual and some perennial broadleaves, yellow nutsedge

- **PSII inhibitors (mobile)**

    - **Metribuzin**

        - Trade name and formulation: Sencor 75DF, Sencor 4L
        - Percent crop treated: 2.2
        - Use rates: 0.250-0.88 lb ai/Ac
        - Application timing: preplant incorporated, pre-emergence (prior to soybean emergence)
        - Pre-harvest interval: none. Do not use for forage.
        - REI: 12 hrs
        - Component of other products: Axiom 68DF, Canopy 75DF, Boundary, Domain
        - Primary use: Annual broadleaves
        - Notes: Crop injury potential greater on alkaline or low organic matter soils and shallow (<1.5 inch) seeded soybeans

- **Shoot inhibitors**

    - **Alachlor**

        - Trade name and formulation: Lasso 4EC, Lasso II 15G, Partner 65DF, CropStar 20G
        - Percent crop treated: NA
        - Use rates: 1.5-4.0 lb ai/Ac
        - Application timing: early preplant (up to 30 days prior to planting), preplant incorporated, pre-emergence
        - Pre-harvest interval: none
        - REI: 12 hrs
        - Component of other products: Freedom 3EC
        - Primary use: Annual grasses and small seeded annual broadleaves
        - Notes: restricted use herbicide

    - **Dimethenamid**

        - Trade name and formulation: Frontier 6EC, Outlook
        - Percent crop treated: NA
        - Use rates: 0.76-1.46 lb ai/Ac
        - Application timing: early preplant, preplant incorporated, pre-emergence, early postemergence (up to 3rd trifoliate stage of soybeans)
        - Pre-harvest interval: none

        - REI: 12 hrs
        - Component of other products: Detail 4.1EC
        - Primary use: Annual grasses and small seeded annual broadleaves

    - **Flufenacet**

        - Trade name and formulation: Axiom 68DF and Domain 60DF (a premix with metribuzin)
        - Percent crop treated: NA
        - Use rates: 0.34-0.60 lb ai/Ac
        - Application timing: preplant, preplant incorporated, pre-emergence
        - Pre-harvest interval: none. Do not graze or harvest for forage.
        - REI: 12 hrs
        - Component of other products: Axiom, Domain
        - Primary use: Annual grasses and small seeded annual broadleaves

    - **Metolachlor and S-Metolachlor**

        - Trade name and formulation: Dual II 7.62 EC, Dual II Magnum 7.64EC, Dual II G Magnum 16G
        - Percent crop treated: NA
        - Use rates: 0.96-2.48 lb ai/Ac
        - Application timing: fall applied, early preplant (up to 30 days prior to planting), preplant incorporated, pre-emergence
        - Pre-harvest interval: none
        - REI: 24 hrs
        - Component of other products: Boundary
        - Primary use: Annual grasses and small seeded annual broadleaves

- **Root inhibitors**

    - **Ethalfluralin**

        - Trade name and formulation: Sonalan 3HFP
        - Percent crop treated: NA
        - Use rates: 0.47-1.12 lb ai/Ac
        - Application timing: preplant incorporated (within 2 days after applications)
        - Pre-harvest interval: none. Do not graze or feed treated forage.
        - REI: 12 hrs
        - Component of other products:
        - Primary use: Annual grasses and small seeded annual broadleaves

- **Pendimethalin**
    - Trade name and formulation: Prowl 3.3EC, Pendimax 3.3 EC
    - Percent crop treated: 22
    - Use rates: 0.56-1.31 lb ai/Ac
    - Application timing: preplant incorporated, preplant surface, pre-emergence
    - Pre-harvest interval: none. Do not graze or harvest for forage or hay.
    - REI: 12 hrs
    - Component of other products: Pursuit Plus 3.0 L
    - Primary use: Annual grasses and small seeded annual broadleaves
- **Trifluralin**
    - Trade name and formulation: Treflan 4 MTF, Trefla TR10, many generics
    - Percent crop treated: 22
    - Use rates: 0.5-1.0 lb ai/Ac
    - Application timing: preplant incorporated (incorporation required within 24 hours)
    - Pre-harvest interval: none
    - REI: 12 hrs
    - Component of other products: Broadstrike + Treflan 3.65 SC, Freedom 3EC
    - Primary use: Annual grasses and small seeded annual broadleaves

- **Growth regulator**
    - **2,4-D**
        - Trade name and formulation: 2,4-D LV ester 4EC (several products)
        - Percent crop treated: 2
        - Use rates: 0.375-1.0 lb ai/Ac
        - Application timing: burndown (prior to planting. Allow at least 7 days before planting for 0.5 lb applications, and 30 days for application up to 1 lb ai/Ac)
        - Pre-harvest interval: none
        - REI: 48 hrs
        - Component of other products:
        - Primary use: Burndown of broadleaves
    - **2,4-D B**
        - Trade name and formulation: Butoxone 4L, Butyrac 200
        - Percent crop treated: NA
        - Use rates: 0.18-4 lb ai/Ac
        - Application timing: Postemerge as rescue treatment

        - Pre-harvest interval: none
        - REI: 48 hrs
        - Component of other products:
        - Primary use: Rescue treatment for broadleaf weeds primarily common cocklebur

- **Pigment synthesis inhibitor**

    - **Clomazone**

        - Trade name and formulation: Command 4EC, Command 3ME
        - Percent crop treated: 5
        - Use rates: 0.5-1.0 lb ai/Ac
        - Application timing: early preplant (no later than April 1 south of I-80 and April 10 north of I-80), preplant incorporated, pre-emergence
        - Pre-harvest interval: none. Do not graze or feed treated soybean forage.
        - REI: 12 hrs
        - Component of other products: Command X-tra
        - Primary use: Annual grasses and annual broadleaves

- **(PPO)**

    - **Aciflurofen**

        - Trade name and formulation: Blazer 2S
        - Percent crop treated: 4
        - Use rates: 0.125-0.375 lb ai/Ac
        - Application timing: postemergence
        - Pre-harvest interval: 50 days. Do not use treated plants for forage.
        - REI: 48 hrs
        - Component of other products: Galaxy, Storm, Manifest, Conclude
        - Primary use: annual broadleaves

    - **Flumiclorac**

        - Trade name and formulation: Resource 0.86EC
        - Percent crop treated:
        - Use rates: 0.027-0.054 lb ai/Ac
        - Application timing: postemergence
        - Pre-harvest interval: 60 days. Do not graze treated areas or harvest for forage or hay.
        - REI: 12 hrs
        - Component of other products: Stellar 3.1EC

        - Primary use: Annual broadleaves

    - **Fomesafen**

        - Trade name and formulation: Flexstar 1.88ME, Reflex 2LC
        - Percent crop treated: 7
        - Use rates: 0.18-0.25 lb ai/Ac
        - Application timing: postemergence (before soybean blooming)
        - Pre-harvest interval: none. Do not graze or feed treated forage.
        - REI: 24 hrs
        - Component of other products:
        - Notes: Do not apply to any field more than once every two years
        - Primary use: Annual broadleaves

    - **Lactofen**

        - Trade name and formulation: Cobra 2EC
        - Percent crop treated:
        - Use rates: 0.09-0.2 lb ai/Ac
        - Application timing: postemergence up to R6
        - Pre-harvest interval: 45 days. Do not use straw or hay for animal feed or bedding.
        - REI: 12 hrs
        - Component of other products: Stellar 3.1EC
        - Primary use: Annual broadleaves

    - **Sulfentrazone**

        - Trade name and formulation: Authority 75DG
        - Percent crop treated: NA (Registered 1998)
        - Use rates: 0.19-0.25 lb ai/Ac
        - Application timing: early preplant (up to 30 days), preplant incorporated, pre-emergence before soybeans emerge
        - Pre-harvest interval: none. Do not graze or feed treated soybean forage.
        - REI: 12 hrs
        - Component of other products: Gauntlet, Command Xtra
        - Primary use: Annual grasses and annual broadleaves

- **Unclassified**

    - **Glyphosate**

        - Trade name and formulation: Roundup Custom 4S, Roundup Ultra 3S, Roundup

Original 3S, Glyphomax 3S, Glyphomax Plus 3S, Roundup Ultra Dry 64.9% DF, etc.
- Percent crop treated: 26
- Use rates: 0.19-3.0 lb ai/Ac
- Application timing: pre-emergence to 30 inches or V8 growth stage.
- Pre-harvest interval: 7 days. Do not feed or graze treated forage.
- REI: 4 hrs
- Component of other products: Extreme
- Primary use: non-specific weed control

- **Glyphosate**

  - Trade name and formulation: Touchdown
  - Percent crop treated: NA
  - Use rates: 0.5-4 lb ai/Ac
  - Application timing: emergence to 30 inches or V8 growth stage.
  - Pre-harvest interval: 90 days. Do not feed or graze treated forage.
  - REI: 4 hrs
  - Component of other products:
  - Primary use: non-specific weed control

- **Paraquat**

  - Trade name and formulation: Gramoxone Max 2.5
  - Use rates: 0.25-1.0 lb ai/Ac
  - Application timing: Pre-emergence burndown, pre-harvest dessicant
  - Pre-harvest interval: 15 days. Do not feed or graze treated forage.
  - REI: 12 hrs (24 hrs as harvest aid)
  - Component of other products:
  - Notes: Restricted use herbicide
  - Primary use: non-specific weed control, harvest aid

Estimated herbicide applications to Minnesota soybeans as percentage of acres treated in 1998 are shown above. Compounds without a percentage listed were labeled past 1998 or use estimates were <2% of acres treated. These figures have likely changed with Glyphosate receiving an increase percentage of herbicide treatment as a result of the widespread adoption of Roundup-ready soybeans. Use rates do not reflect all tank mix options.

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