Crop Profile for Sunflowers in North Dakota

Prepared: September, 1999

General Production Information

The sunflower is native to North America, and is the state flower of Kansas. Sunflower use has been documented back to the day when Native Americans used the sunflower for food. There are two basic types of sunflowers grown in North America: (1) Those used for oilseed production and (2) non-oilseed, or confectionery, used for the food and birdseed markets.

Oilseed sunflower seeds are usually smaller and are black in color. Oilseed hybrids generally have a thin hull that adheres to the kernel. Oilseed varieties can contain from 38 to 50 percent oil and about 20 percent protein. This seed produces a major source of the vegetable oil for the US and the world.

Non-oilseed or confectionery sunflowers have striped hulls and are the larger of the two seed types. The seeds are usually thick hulled and loosely attached, allowing for a more complete dehulling. Confectionery sunflowers are usually lower in oil content and test weight.

In 1997, North Dakota ranked number one in U.S. sunflower production. North Dakota produced 48% of all oilseed production, 58% of all non-oilseed production, and 50% of all sunflower production. South Dakota, Kansas, and Minnesota were behind North Dakota in production.

In 1998, North Dakota producers harvested 1.99 million acres. The average yield was 1,517 lbs/a, for a total of 2.97 billion pounds of sunflowers. Oilseed sunflower were harvested from 1,600,000 acres for a total of 2.43 billion lbs. Non-oilseed sunflower were harvested from 380,000 acres for a total of 539 million lbs.

Table 1. Sunflower production and its economic contribution to North Dakota agriculture (NDASS, 1999).

Year	Oilseed			Confectionery			Value of Production All Sunflowers (000 Dols.)	US Ranking of Production All Sunflowers	Percent of Nation All Sunflowers
	Acres (x1000)	Avg. Yield (lbs/ A)	Value ($) Per Harvested Acre	Acres (x1000)	Avg. Yield (lbs/ A)	Value ($) Per Harvested Acre			
1993	970	840	103.32	195	780	118.56	123,339	1	37
1994	1,310	1,450	146.45	225	1,350	194.40	235,590	1	46

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1995	1,210	1,250	140.00	190	1,230	180.81	203,754	1	44
1996	890	1,500	163.50	275	1,450	221.85	206,524	1	48
1997	1,110	1,330	147.63	310	1,290	185.70	219979	1	50
1998	1,600	1,580	na	380	1,420	na	na	1	57

Cultural Practices

Sunflowers are grown throughout the state of North Dakota. Sunflowers are grown on well drained soils that have a high to intermediate water holding table, and a pH of 6.5 to 7.5 for best results. Sunflowers are planted on a four year or longer rotation to break disease cycles and insect problems. Sunflowers are usually planted from early May until mid June, once soils have reached 45ºF or above at the 4" depth. Typical row spacings for planting are between 20-30", but good yields have been documented from 14 to 40 inch rows, with solid seeding an option. Plant populations are 15-25,000 plants per acre for oilseeds and 14-20,000 plants per acre for confectionery. Sunflower harvest begins in late September with a typical growing season of 120 days. Desiccants are used to dry down the plant when needed to prevent late season disease losses or to hasten harvest.

Sunflower Processing and Marketing

Sunflower is a light-weight seed (28 pounds/bushel). This limits the distance that sunflower seed can be shipped economically. Thus, most of the production is processed close to where it is produced. Confectionery sunflower is the edible product that is consumed as a snack or an ingredient in a variety of food products such as bread. The hull surrounding the kernel is removed by an impact huller. The hulls and kernels are separated. Kernels can be sold as raw or roasted. Kernels are roasted in vegetable oil at 300 to 374 F for 3 to 6 minutes. Roasted kernels are often packed as a snack. Raw kernels are further packaged and sold as an ingredient for breads and a variety of other processed food products.

The extra large confection seeds are processed for the snack market. The first processing step is to remove all foreign material by separators. For domestic use, these large in-shell seeds are processed in a salt brine which may include other spices for flavor. The seeds are then roasted in ovens with temperatures ranging from 300 to 400 degrees F. There are eight major confection processing plants in the US with the majority located in North Dakota. There are a number of smaller plants that further process both in-shell sunflower seeds and sunflower kernels into consumer ready product.

Most of the oil-type sunflower is processed into oil and meal in large, efficient processing plants. The oil-type sunflower contains about 43 percent oil (with the shell). There are four such plants in the US. Two are located in North Dakota, one in Minnesota and one in Kansas. Some of the plants partially hull the sunflower seed prior to crushing. This is accomplished by impact hulling. The remaining seed is then heated to 180-240 degrees F and flaked. It is pressed by a mechanical expeller or press. This process removes about half of the oil content. The material is then placed in a solvent extraction process where the remaining oil is removed by a chemical 'washing' action. The remaining meal (oil removed) is toasted, cooled and sold as animal feed. The oil is either exported as crude oil or refined for domestic consumption. The refining process includes a degumming process where hot water is added to the oil and the combination is centrifuged. The oil is further bleached and deodorized by a heating/cooling process and final filtering.

Recently the sunflower industry has developed new sunflower hybrids that contain a fatty acid constituency that functions very well in industrial frying operations. This oil does not require hydrogenation for most frying mediums, thus there is no trans fatty acid byproduct.

Another oil-type sunflower seed market is the birdseed market. This market has developed into a substantial size over the last 10 years. The black oil-type sunflower seed is the preferred food source for many species of wild birds. Seed is cleaned using conventional cleaning systems and bagged. Bird feeding is the second most popular hobby among American adults. There are many small businesses that bag and market bird food in the rural sunflower production areas.

Insect Pests

Insect damage to sunflowers may cause substantial loss and economic hardships come harvest. Insect populations may be influenced by the previous year's populations, winter conditions, and the current years' conditions in the Northern Plains. Without season long monitoring, damaging population levels may go unnoticed in sunflowers. Most insect damage often goes unnoticed due to small injury areas within the field or is often mistaken for disease or other problems.

Scouting to estimate insect population levels should occur weekly. Scouting should be done during peak activity times of major pest insects to determine if control is needed.

Insecticide use was reported on 40% of sunflowers in 1996 (Zollinger, et al, 1998). In 1997, 98% of the respondents acres were treated once; with 8% of the acres were treated twice (Lamey, et al., 1999). Aerial application was used on 69% of acres, with 31% of application being done by ground rigs.

In 1997, survey respondents from North Dakota reported that the sunflower beetle was the worst insect

on 58% of their total acres. The sunflower midge was reported to be the second worst pest on 13%. The stem weevil and seed weevil were in third and fourth on 7% and 6%, respectively. Grasshoppers were fifth on 3%; with the banded sunflower moth and cutworm coming in sixth and seventh on 2% and 0.5%, respectively.

Insecticides used most commonly during 1997 on North Dakota respondents' acres were: Asana XL on 41%, Warrior on 15%, and Lindane/Maneb, a seed treatment, on 2% of the total acres.

The most recent pesticide use surveys for North Dakota indicate a major shift in insecticide use by sunflower growers in the state. The pyrethroid insecticides have been more widely used in the region than any other class of insecticide. This shift is largely due to a change in occurrence of economic insect pests during the mid-90's. Pyrethroids have been very effective at controlling the foliage feeding insects which have been most prevalent. In previous years, head infesting insects have been the most important insect pests. The organophosphate insecticides, parathion and methyl parathion, generally provide better control of head feeding insects. Chemical properties of these insecticides increase their movement to the insects' hiding sites among the bracts and florets of the sunflower head. The parathions were still the most widely used insecticides in Kansas where the Sunflower head moth, *Homoeosoma electellum*, was the most often targeted insect pest, (Lamey et al., 1999).

Non-chemical control practices used in 1997 by producers in North Dakota were: crop rotations on 58% of total respondents' acres, tillage used on 30% of acres, and hybrid selection used on 10% of the total acres.

There are approximately 15 species of insects in the Dakotas and Minnesota but only 7 species may warrant control yearly.

Cutworms - Plant damage from cutworms can occur from planting until the end of June. The larvae feed on the foliage or cut the plant 1" below ground to 1 to 2" above ground. Most cutworms feed at night; scouting is recommended during the day, looking below the soil surface near newly damaged plants. Wilted, cut plants, or bare random patches in the field may indicate cutworm activity. Treatment with post emergence insecticides is warranted when one cutworm is found per square foot or if there is a 25 - 30% stand reduction observed.

Sunflower Beetles - Sunflower beetle (*Zygogramma exclamationis*) feeding damage occurs from plant emergence until maturity; however, the most serious damage occurs from mid June to mid July when larvae are actively growing. Both adults and larvae chew holes in the first true leaves. The beetles feed during the evening and can be found resting underneath the leaves or in the plant terminal during the day. Weekly scouting to determine the need for control is recommended. Treatment with post emergence insecticides is recommended when 1 to 2 adults are found per seedling; or when 15 to 20 larvae are found per plant.

Spotted Sunflower Stem Weevil - Stem weevil (*Cylindrocopturus adspersus*) damage occurs when

adults lay eggs in the lower portion of the stalk. Larvae hatch in early July and began feeding on the subepidermal, vascular, and finally pith tissue. Larvae form an overwintering cell near the base of the stalk in late summer. When larvae total 25 to 30 or more per stalk, stalks are weakened and are susceptible to breakage during high winds or drought conditions. Most management is directed at the adult stage. When populations are large, systemic insecticides applied at planting are effective at controlling larvae in the stalk. Scouting for the adults is recommended from mid June to mid July. Treatment is warranted when there is one adult found per three plants.

Banded Sunflower Moth (*Cochylis hospes*) - Larvae feed first on the bracts, then move to the florets. The larvae will feed on the florets until the third instar. As seeds form, the larvae tunnel into the top of the seed. The larvae may consume part or all of the contents of the seed; exiting from the same hole as they entered. A single larva may destroy 5 to 7 seeds. Small areas of silken webbing in mature heads indicate larval feeding. Scouting should occur from mid July to mid August when the adults are most active. Treatment is recommended when 1 to 2 moths are found for every 2 plants inspected. Treatments along field margins during peak activity in mid July to mid August may reduce adult moth populations.

Red Sunflower Seed Weevil (*Smicronyx fulvus*) - Scouting is critical as soon as the yellow ray petals appear. Egg laying begins after female weevils feed on pollen. Adult weevils lay a single egg in each seed. Damage occurs when the weevil larva feeds on the developing seed, consuming all or part of it in mid to late summer. The exit hole of the red sunflower seed weevil is on the side of the seed, distinguishing it from banded sunflower moth which produces a feeding hole on the top of the seed. Mosquito repellent is used to flush weevils out from between the florets for more accurate scouting. Treatment is recommended when 7 to 9 adult seed weevils are found per oilseed head or when 1 to 2 weevils are found per confection sunflower head.

Sunflower Midge - Adult midge (*Contarinia schulzi*) emerge in July and lay eggs on developing sunflower buds. The small maggots feed on the bract tissue, moving later to the florets. The maggots salivary secretions dissolve cell walls and they consume the dissolved material. The salivary secretions result in twisting and gnarled flower heads that may prevent flowering and seed set. Often, infestations are confined to field margins unless large populations are present. No treatment thresholds have been determined because no effective chemical treatment has been found. Rotations, staggered planting dates to promote different budding times, and selecting tolerant hybrids are the only options that help to decrease midge populations and losses.

Grasshoppers - Grasshoppers defoliate sunflower plants. Damage from nymphs, in the early season, and adults, in late summer, can occur. Grasshopper outbreaks can be anticipated based on the previous years' population size and the current year's weather conditions. Grasshopper damage can occur from early June to mid-September. Treatment is recommended when 20 or more adults are found per square yard in field margins or 8 to 14 are found in the crop and greater than 30% defoliation has occurring.

Table 2. Registered insecticides and their usage in North Dakota to manage sunflower insect pests.

Active Ingredient	Tradename	% Crop Treated		Application Rate		Insect [3] Controlled	Timing Growth Stage	PHI (Days)	
		1996 [1]	1997 [2]	Labeled	Typical			Labeled	Actual
esfenvalerate	Asana XL	24.6	40.8	5.8-9.6 fl oz	5.8 fl oz	CW	seedling	28	120
				2.9-5.8 fl oz	1.0-2.8 fl oz	SB	seedling - vegetative	28	100
				5.8-9.6 fl oz	5.8 fl oz	SSW	vegetative	28	91
				5.8-9.6 fl oz	5.8 fl oz	RSSW, BSM, GH	flowering	28	56
cyfluthrin	Baythroid	na	na	1.6-2.8 fl oz	1.0-1.6 fl oz	SB	seedling - vegetative	30	100
				2.8 fl oz	2.8 fl oz	BSM, RSSW	flowering	30	56
carbofuran	Furadan 4F	1.2	1.4	0.25-1 pt	0.25 pts	SB	seedling - vegetative	28	100
				1.4 qts	1.4 qts	SSW	pre-plant	28	130
chlorpyrifos	Lorsban 4E	0.2	0.2	2 - 4 pts	2 pts	CW	seedling	42	120
				1-1.5 pt	1 pt	SB	seedling - vegetative	42	100
				1 pt	1 pt	SSW	vegetative	42	91
				1-1.5 pt	1 pt	GH, BSM, RSSW	flowering	42	56
chlorpyrifos	Lorsban 15 G	0	0	8 oz/1000 ft	8 oz/1000 ft	CW	seedling	0	0
methyl parathion	Methyl Parathion	na	na	0.75-1 pt	0.75 pts	RSSW	flowering	30	56
methyl parathion	Penncap-M	na	na	0.75-1 pt	0.75 pts	RSSW	flowering	30	56
6-3-methyl parathion	6-3-methyl parathion	na	na	0.88pt	. 88 pts	RSSW, GH	flowering	30	56

tralomethrin	Scout X-TRA	0.9	1.4	0.71-1.4 fl oz	0.71 fl oz	SB	seedling-vegetative	21	100
				2-2.33 fl oz	2 fl oz	SSW	vegetative	21	91
				2-2.33 fl oz	2 fl oz	RSSW, BSM,GH	flowering	21	56
carbaryl	Sevin XLR	0.6	0.6	1.5 qts	1.5 qts	CW	seedling	60	120
				rates vary by formulation		GH	flowering	60	56
				20-40 lbs	20 lbs	CW	bait	0	0
lambda cyhalothrin	Warrior	10.7	14.9	1.28-2.56 fl oz	1.28 fl oz	SB	seedling - vegetative	45	100
				1.28-2.56 fl oz	1.28 fl oz	CW	seedling	45	120
				2.56-3.84 fl oz	2.56 fl oz	SSW	vegetative	45	91
				2.56-3.84 fl oz	2.56 fl oz	RSSW, BSM, GH	flowering	45	56

[1] Zollinger et al, 1999.
[2]Lamey et al, 1999.
[3]BSM - Banded Sunflower Moth, SSW - Sunflower Stem Weevil, RSSW - Red Sunflower Stem Weevil, CW - Cutworm, GH - Grasshopper, SB - Sunflower beetle
na - not available

New advancements in Insect Management

Diseases

Sunflower diseases are difficult to avoid in North Dakota, but the incidence and severity can be managed

to prevent severe losses. Diseases may get the blame for losses in sunflowers when insects, herbicides, or soil problems were the true problem. Disease problems occurring in a field may be very obvious or not be detected even to a watchful eye. Sunflower diseases may cause plants to die off at an early stage and reduce sunflower stands; or plant stands may establish with great expectations and then be lost during the growing season. Weather conditions greatly affect disease potential and inoculum levels in the environment. Wet, cool years harbor different pathogens of sunflower than hot, humid conditions.

In North Dakota, plant pathologists report that Sclerotinia wilt, Sclerotinia head rot, Phomopsis stem canker, rust, and downy mildew are the five worst diseases that producers encounter.

Sclerotinia Wilt - Sclerotinia (*Sclerotinia sclerotorium*)overwinters in the soil or on plant debris as sclerotia. When sunflower roots come in contact with sclerotia, they germinate, infecting and decaying the roots. Infection moves up the roots and into the lower stem, causing the plant to wilt and die rapidly. Surviving plants are smaller than healthy plants and may or may not produce seed. Symptoms are sudden wilting of the leaves, root rot, stem canker, and production of sclerotia in the stem. Wilted plants usually are first seen during flowering, but 60-70% of wilting occurs after flowering. Infection and death of neighboring plants occurs when diseased roots come in contact with healthy ones. Plants lodge during high winds. Refer to the head rot section for management recommendations.

Sclerotinia Head Rot - High soil moisture for seven to 14 days, usually from mid June until mid September, promotes the germination of sclerotia to form apothecia, which produce millions of ascospores. The spores are ejected into the air and may be carried to nearby fields or even for miles. When they land on the sunflower heads, they infect the receptacles (fleshy back of the head) in wet weather causing decay of the entire head. Head rot can first be recognized by brown water soaked spots on the receptacles. Later, large areas may become bleached. The fungus can destroy the entire head, leaving only a bleached, shredded skeleton filled with sclerotia and seeds that shatter and are lost during harvest. Head rot decreases oil content and increases free fatty acid content. Management of Sclerotinia includes: avoid planting on infested fields with sclerotia present, avoid solid seeding and high plant populations, scout fields to monitor for disease incidence at flowering and later, use crop rotations to non-susceptible hosts, choose the least susceptible hybrids, and do not plant adjacent to fields with a history of Sclerotinia to reduce head rot incidence from wind-blown spores.

Phomopsis Stem Canker - Infection begins at the leaf margins. The disease progresses from leaf margins through leaf veins to the petiole, and finally the stem; stem lesions appear at flowering. Phomopsis (*Phomopsis helianthi*) thrives well under prolonged high temperature and high humidity. Yield losses result from smaller heads, lighter seed, and lodging. Phomopsis is identified by large tan to light brown lesions which typically surround the leaf petiole. The lesion may reach 6 inches in length, is light in color, and has an indefinite and sunken border. As the crop matures, the entire stalk may develop a silvery appearance and become very brittle. Management is achieved through crop rotations and tillage to bury crop residue.

Sunflower Rust - The rust fungus (*Puccinia helianthi*)overwinters on plant debris, germinates in the

spring, and infects volunteer seedlings and wild sunflowers. Later, rust spores are spread by wind from the volunteer or wild sunflower plants to the current year's sunflower crop. Warm temperatures and rain or dew favor fast multiplication of the rust. High nitrogen rates and high seeding rates increase leaf area which increases humidity in the crop canopy favoring rust development. Damage includes reduced yield, oil content, seed size, test weight, and kernel-to-hull ratios. Rust infections are recognized by cinnamon colored spots on the leaves, stems, petioles, bracts, and the back of the head. The spots turn black with the arrival of cool temperatures in late summer. Management is most successful with resistant hybrids, but most hybrids do not have resistance to all of the newest races present in North Dakota and other major U.S. sunflower producing areas. The incidence of rust can be reduced by destroying wild or volunteer plants, not planting susceptible varieties near one another, avoiding higher than needed rates of nitrogen fertilizer, and planting to establish recommended plant populations.

Downy Mildew - Downy Mildew (*Plasmopara halstedii*) is both soil-borne and wind-borne. The downy mildew fungus is occasionally seed-borne. Under cool, water-saturated soil conditions the spores germinate, enter the sunflowers roots, and spread throughout the plant. Infected seedlings often die; plants that survive are stunted with erect, platform heads and little or no seed. Infected seedlings have yellow leaves. Plants infected after the seedling stage develop thickened, club-like roots, are stunted, but do not show any foliar symptoms. Wind-blown spores may adhere to leaves and cause small, localized, angular chlorotic spots. During periods of high humidity, the underside of the leaf may be covered with a white, downy growth. Downy mildew is managed by using resistant varieties, rotating crops, avoiding poorly drained fields, planting in uninfected fields, controlling wild and volunteer sunflowers, using a fungicide seed treatment, or delaying planting until soil temperatures favor rapid growth of seedlings. Most currently available hybrids are not resistant to all common races of the downy mildew fungus. Recently, the fungus has developed resistance to metalaxyl and mefenoxam, the most common seed treatments used for downy mildew control. Search for a suitable alternative is underway.

In 1997, surveyed North Dakota growers (Lamey et al, 1999) reported that the worst disease problem on their acres was Sclerotinia, with head rot the worst on 27%, followed by sclerotinia wilt on 22% of respondents' acres. Phoma black stem was reported as the worst disease on 14% of respondents acres. Rust and downy mildew on 4% and 2% were the fourth and fifth worst disease problems of respondents' acres, respectively. Phomopsis and Rhizopus head rot were other diseases reported in 1997, but no occurrence of charcoal rot or white rust was reported in North Dakota.

Respondents reported sclerotinia head rot incidence of 0 to 40% in North Dakota, with 81% reporting less than 10 % damage from head rot, 9% reporting between 11-20% damage, 6% estimating 21-30% damage, and 4% reporting 31-40% damage from head rot. Sclerotinia wilt was reported to produce between 0 and 90% lodging on sunflowers. Respondents reported that 70% of producers had less than 10% lodging, 18% had 11-20% lodging, 6% had 21-30 % lodging, 2% reported 31-40% lodging, none reported lodging damage between 41-50%, and 1% of respondents each reported 51-60%, 61-70%, 71-80%, and 81-90% lodging percent.

In 1997, 61% of respondents in North Dakota used crop rotations as the number one non-chemical disease management practice. Tillage and resistant hybrids were second and third at 26% and 14%,

respectively.

Table 3. Fungicide seed treatments used in North Dakota sunflower production.

Active Ingredient	Tradename	Application Labeled Rate *	Disease Control		Application Type
			Seedling Blight	Downy Mildew	
captan	Captan 30 DD, 28.7%	4 fl oz/cwt	good	none	slurry
	Captan 400, 37.4%	2-4 fl oz/cwt	good	none	slurry
	Nu-Gro Captan 4000, 38.7%	2-4 fl oz/cwt	good	none	slurry
fludioxonil	Maxim 4FS	0.08-0.16 fl oz/ cwt	excellent	none	slurry
maneb	DB-Green L, 25.6%	4 fl oz/cwt	good	none	liquid or slurry
mefenoxam	Apron XL LS, 32.34%	1.28 fl oz/cwt	not registered	excellent **	slurry
metalaxyl	Alligence FL, 28.35%	1.5 fl oz/cwt	not registered	excellent **	mist or slurry
	Apron 25W, 25%	4 oz/cwt	not registered	excellent **	liquid or slurry
	Apron FL, 28.35%	3 fl oz/cwt	not registered	excellent **	liquid or slurry
	Apron Flowable, 28.35%	3 fl oz/cwt	not registered	excellent **	liquid or slurry
	Apron Dry Seed Protectant,12.5%	8 oz.cwt	not registered	excellent **	drill box
	Apron TL, 11.5%	8 fl oz/cwt	not registered	excellent **	liquid or slurry
oxadixyl	Anchor, 31%	3 fl oz/cwt	not registered	excellent **	liquid or slurry
thiram	42-S Thiram, 42%	2 fl oz/bu	good	none	liquid or slurry

* All of these applications are for seed treatment only
** Ranking of sensitive strains. Resistant strains are common in North Dakota, Minnesota, and South Dakota.

New Advancements in Disease Management

Folicur (tebuconazole) and Topsin M (thiophanate-methyl) fungicides are in the IR-4 program for minor use registration. Field residue trials and laboratory residue analysis for both have been completed and results will be submitted to EPA in the year 2000. Folicur is to be registered for foliar application for control of rust; Topsin M will be registered for seed treatment to control seed-borne Sclerotinia in years

when head rot is severe in seed production fields.

Table 4. The 1998 and 1999 emergency exemption, Section 18, issued for tebuconazole in North Dakota for sunflower production.

Active Ingredient	Tradename	Application Labeled Rate *	Disease Control sunflower rust	Timing Growth Stage	PHI (days)	Application Type
tebuconazole	Folicur	4 fl oz per acre	excellent	bud - flowering	50	foliar

Weeds

Weeds are a continuous production problem in sunflowers. Weed control practices on sunflowers in North Dakota are accomplished through the use of herbicides, tillage, and rotation. Weeds management is one of the greatest concerns of growers during the first four weeks of growth. Weed control at this time is essential to maximize returns from sunflowers.

In 1996, herbicides were used on 95% of all sunflower acres (Zollinger et al, 1999). Surveyed growers identified foxtail as the worst weed problem on 29% of their acres (Lamey et al, 1999). Wild mustard and Canada thistle ranked second and third at 19.1% and 19.0%, respectively. Cocklebur at 9% and kochia at 5.5% finish out the top five worst weeds in producers' acres. Other weeds which are also problems include: wild oats, Russian thistle, redroot pigweed, common lambsquarters, field bindweed, wild sunflower, nightshade, quackgrass, and volunteer cereals.

Green foxtail (*Setaria viridis*) and **yellow foxtail** (*S. glauca*) are the most abundant grassy weeds found in North Dakota. Foxtails are late spring emerging weeds. Foxtail plants can be numerous in a sunflower field, but can easily be controlled with most herbicides.

Wild Mustard (*Sinapis arvensis*) emerges early and is most competitive early in the season. Wild mustard can continue to emerge with timely rains and continues to be a problem throughout the season. Assert (imazamethabenz) is the only herbicide presently registered for use in sunflower which controls wild mustard. Herbicides used in rotations with other crops are the best means for control in sunflower fields.

Canada Thistle (*Cirsium arvense*) is a perennial weed that competes with sunflower causing significant

yield reductions. No chemical selectively controls Canada thistle in sunflower. However, glyphosate is registered for preemergence use and use with shielded sprayer between sunflower rows. Fall herbicide applications, herbicide use in rotations with other crops, and selecting fields low in populations of Canada thistle are good management practices.

Common Cocklebur (*Xanthium strumarium*) can cause yield reductions and large discounts in price if numerous cocklebur seeds are found in with sunflowers seeds at time of sale. Common cocklebur is an annual that emerges later in the growing season. No chemical selectively controls common cocklebur in sunflower. Common cocklebur between sunflower rows can be controlled with shielded applications of glyphosate. However, cocklebur should be controlled in other crops in rotation with sunflower that has more effective chemical options.

Kochia (*Kochia scoparia*) can emerge early during cool periods in the spring or later with warm temperatures and adequate moisture. Kochia can become a very large plant and cause competition with sunflowers throughout the season. Preplant incorporated applications of ethalfluralin and trifluralin provides fair to good control of kochia. Crop rotations with more effective chemical options help reduce kochia infestations.

In 1997, the herbicides most frequently used on survey respondents' acres were Sonalan (ethalfluralin) on 43% and trifluralin on 30% of North Dakota respondents acres, both applied as preplant incorporated in the spring (Lamey et al, 1999). The postemergence herbicides, Assert (imazamethabenz) for wild mustard and Poast (sethoxydim) for annual grasses, were the next most common herbicides, applied on 9.7% and 9.5% of respondents acres, respectively. A single herbicide application was used on 99% of the respondents' acres.

Sunflowers are limited to a few herbicides so producers look for alternative ways to manage weeds. Preplant tillage helps to stimulate and control early weed flushes. Planting is done immediately after tillage to establish sunflowers which compete better with the weeds. Cultivation is an effective cultural control method. In 1997, survey respondents used cultivation on 64% of their acres, of which, 85% of these acres were cultivated once, 13% twice, and 2% were cultivated three times (Lamey et al, 1999). Crop rotations permit the use of herbicides with different modes of action for weeds that are difficult to control when sunflowers are planted.

Table 5. Registered herbicides and their usage in North Dakota to manage sunflower weed pests.

Active Ingredient	% Crop Treated		Tradename	Application Rate		Timing/ Growth Stage	Weeds Controlled
	1996 [1]	1997 [2]		Labeled	Typical		
			Roundup Ultra	0.5 to 2	1.5 pt		

glyphosate	0.8	5.4	Roundup	pt		preplant or prior to crop emergence	emerged grass and broadleaf
			Glyphos				
			Roundup Custom	2 to 3 pt	2 pt		
EPTC	1.2	2.1	Eptam 7-E	2.5 to 3.5 pt	3 pt	preplant	grass and some broadleaf
				4.5 to 5.25	5 pt	fall preplant	
			Eptam 20G	20 to 22.5 lb	22 lb	fall preplant	
ethalfluralin	43.4	43.9	Sonalan	1.5 to 3 pt	3pt	preplant spring or fall	grass and some broadleaf
			Sonalan 10G	5.5 to 17 lb	15 lb		
				7.5 to 12.5 lb	10 lb		suppress foxtail
ethalfluralin + EPTC	na	1.3	Sonalan + Eptam 20G	1.25 to 3 pt + 11 to 15 lb	2.5 pt + 12 lb	preplant	grass and some broadleaf
pendimethalin	0.6	0.4	Prowl	2.4 to 3.6 pt	3 pt	preplant	grass and some broadleaf
				3 to 3.6 pt	3 pt	surface applied	
				2.4 to 4.24 pt	4 pt	fall preplant	
trifluralin	35.2	35.2	Trifluralin	1 to 2 pt	2 pt	preplant	grass and some broadleaf
			Treflan TR-10	5 to 10 lb	10 lb	fall or spring preplant	
trifluralin + EPTC	na	3.1	Trifluralin + Eptam	1 pt + 7.5 to 10 lb	1 pt + 7.5 lb	preplant	grass and some broadleaf
sulfentrazone	Sect 18, 1999		Spartan	2.67 to 5.33 oz	4.27 oz	preplant, conservation tillage	small seeded broadleaf
imazamathabenz	5.8	9.7	Assert	0.6 to 0.8 pt	0.6 pt	postemerge	wild mustard

sethoxydim	7.1	9.5	Poast	0.5 to 1.5 pt	1 pt	postemerge	annual grases
paraquat	na	na	Gramoxone	1 to 1.5 pt	1.5 pt		dessicant
sodium chlorate	na	0.6	Defol	1 to 2 gal	2 gal		dessicant

[1]Zollinger et al, 1999.
[2]Lamey et al, 1999.

New advancements in Weed Management

Sulfentrazone (Spartan) was used in sunflower grown in the U.S. in 1999 through Section 18 emergency registration. Use allowed through Section 18 will be requested again in 2000. Federal registration is expected in 2001. Spartan applied PRE at 2.67 to 5.33 oz WDG/A controls most annual small-seeded broadleaf weeds such as, biennial wormwood, kochia, common lambsquarters, waterhemp, pigweed species, nightshade species, and annual smartweeds. Spartan may suppress other weeds like buckwheat, mustard, ragweed, and Russian thistle. Spartan has some grass and no perennial weed control. Spartan requires precipitation for activation. Spartan has adequately controlled weeds listed above and many different environments through out the Plains and Great Plains region. However, consistent control of sensitive broadleaf weeds and control of grass and marginally controlled broadleaf weeds greatly depends on rainfall shortly after application and before weeds emerge. At least one inch of rain is required after application for optimum weed control. Adjust rate for soil type. Sunflower has shown good safety to Spartan on medium to fine textured soils with organic matter above 3%. Spartan is a PPO inhibitor mode of action herbicide. Pre-emergence application rather than requirement for incorporation allows use in no-till sunflower production. Spartan has excellent burndown weed control for early pre-plant applications. No plant resistance has been documented to herbicides of this mode of action.

Another advancement in weed control includes the development of herbicide resistant crops. Herbicide resistant crops are developed through transgenic gene transfer or, in the case of sunflowers, the resistant gene found in wild types is inserted into cultivated species through normal plant breeding techniques. The end result is total crop safety to the herbicide. Some benefits of herbicide resistant crops are full spectrum weed control, wide application window, tillage flexibility, and allowance for rescue treatments for weed control. Sunflower resistance to imidazolinone herbicides (eg: Raptor) is expected through Section 18 registration in the year 2001 and through federal registration in 2002. Sunflowers resistant to glyphosate and sulfonylureas may be available in the future.

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